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study in the
Flathead Valley
area, November,

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AN AIR QUALITY STUDY

OF THE

LIBBY AND FLATHEAD VALLEYS

November, 1968 - August, 1970

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The Montana State Department of Health

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AIR QUALITY STUDY

IN THE

FLATHEAD VALLEY AREA

November, 1968 - August, 1970

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ERRATA SHEET

Cover Page - (Picture) Anaconda Aluminum Company
Columbia Falls, Montana

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Missoula, Montana

Page 13, Table #6, Columbia Falls Sulfur Dioxide 0.037 not 0.37

Page 34, Table #10, units are parts per million fluoride on a dry weight basis.

Page #58, Libby area suspended particulate; delete the following: "the important contributors to the suspended particulate of the area"

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ACKNOWLEDGEMENTS

Grateful appreciation is extended to the many people whose cooperation and participation helped to make this study possible. Particular acknowledgement is due to each of the high volume sampling station operators: H. R. Dehlbom, Roy Anders and Jerry Zoller, Columbia Falls; Lloyd Stevens and Gene Bradford, Kalispell; Earl Walker, Robert E. Sprague and Luther Locock, Libby; Duane Robertson, Polson.

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INTRODUCTION

During the year of June, 1963 to June, 1964, an ambient air quality study of the Flathead Valley was conducted with the objective of determining, as a baseline, the quality and types of specific air contaminants in the air of the Flathead Valley. With this information, future projections on air quality could be made and the effect of certain industrial and domestic practices predicted. During the 18 month period beginning March of 1969 and ending in August of 1970, a more comprehensive study of essentially the same specific air contaminants was made in the hopes of realizing this objective.

With the passage of the Clean Air Act of Montana in 1967 and with the adoption of certain ambient air quality standards, a clear definition of the problems and their magnitude in the area is possible through the means of the study reported. While it is recognized that not all aspects of the air pollution problem are included in this report, the information submitted is sufficient to enlarge the understanding of all of those who are involved in the improvement of the air quality and to those who are contributors to the pollution problem. Recognition by all concerned persons that air pollution is a threat to animal and plant life, human health and comfort and, in some instances, to life itself indicates the necessity of a constantly improving appraisal of available air. The results of this study indicates the urgency and the necessity of improved air pollution control in the Flathead Valley area.

CHARACTERISTICS OF THE FLATHEAD VALLEY

As indicated on Map I, the Flathead Valley, which is about 15 miles wide and 50 miles long, slopes from north to south at a low uniform rate, and lies in a timbered mountainous area of northwest Montana on the western slopes of the Continental Divide. The valley lies within the boundaries of Flathead County to the north and Lake County to the south. Kalispell, located centrally in the valley, has an elevation of approximately 2900 feet. Mountains to the north and east rise an average of 3,100 feet above the valley floor. To the west, the mountain rise is about 4,600 feet on an average. Flathead Lake, a natural lake, located in the southern portion of the valley covers approximately 200 square miles. This large mass of water has a stabilizing effect on the valley weather conditions, and intensifies the Valley's susceptibility to inversion and stagnation conditions. Tables 1 and 2 indicate that a large number of inversions occur during the night and often extend into the day. Wind roses for the area (Figure 1) show extremely light winds. The direction of the wind in Polson located on the southern tip of Flathead Lake suggests a light wind blowing away from the lake at night and towards the lake during the day. Opposing daytime and nighttime wind is also evident at the Kalispell airport north of the lake.

These topographical and meteorological characteristics both intensify the severe air pollution problem that exists in the Flathead Valley. The low wind speeds, the frequency of inversions, the opposing wind directions and the stabilizing effect of Flathead Lake, all point to frequent and severe periods of stagnation of the air in the Flathead Valley.

FLATHEAD VALLEY STUDY AREA
MAP I

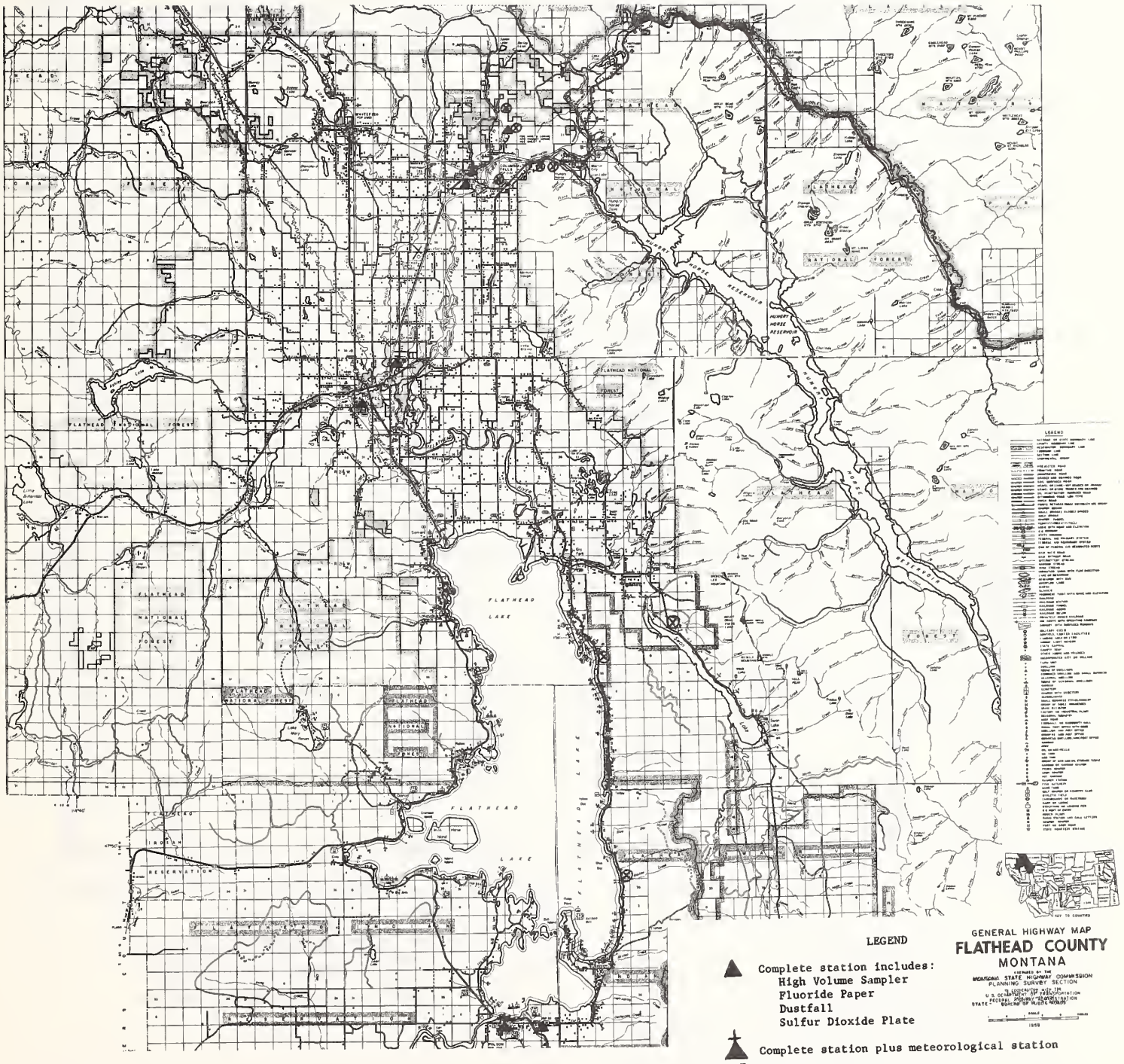


TABLE 1

Inversions Occurring During Night of Any Length
Flathead Valley - 1963

	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	X	X		X	X	X^{s}
2	X	X	X	X		X^{s}
3	X	X	X	X	X	X^{s}
4	X	X	X	X	X	X^{s}
5	X	X	X	X		X^{s}
6	X	X	X	X		
7	X	X	X	X		
8	X	X	X	X		X
9	X	X	X^{s}	X^{s}		
10		X^{s}	X^{s}	X	X^{wk}	
11		X		X		X^{s}
12	X	X	X	X^{s}	X	X
13	X^{s}	X		X^{s}	X	X
14	X	X	X	X	X	X
15		X	X	X		X
16	X^{s}	X	X^{s}	X^{s}		
17	X^{s}	X	X	X^{s}		
18	X	X	X^{s}	X^{s}		X
19	X^{s}	X	X^{s}	X^{s}		X
20	X	X	X	X^{s}		X
21	X	X	X		X	X^{wk}
22	X	X	X^{s}			
23	X^{s}	X	X		X	X^{wk}
24		X	X			X
25		X	X			
26	X		X^{s}	X^{lgt}		X
27	X	X	X^{s}	X^{lgt}		X
28	X	X	X	X^{lgt}		X
29	X		X	X^{wk}	X^{s}	X
30	X^{s}		X	X^{wk}	X^{s}	X
31	X^{s}	X		X		X

X = inversion
X^{s} = strong inversion
X^{wk} = weak inversion
X^{lgt} = light inversion

TABLE 2

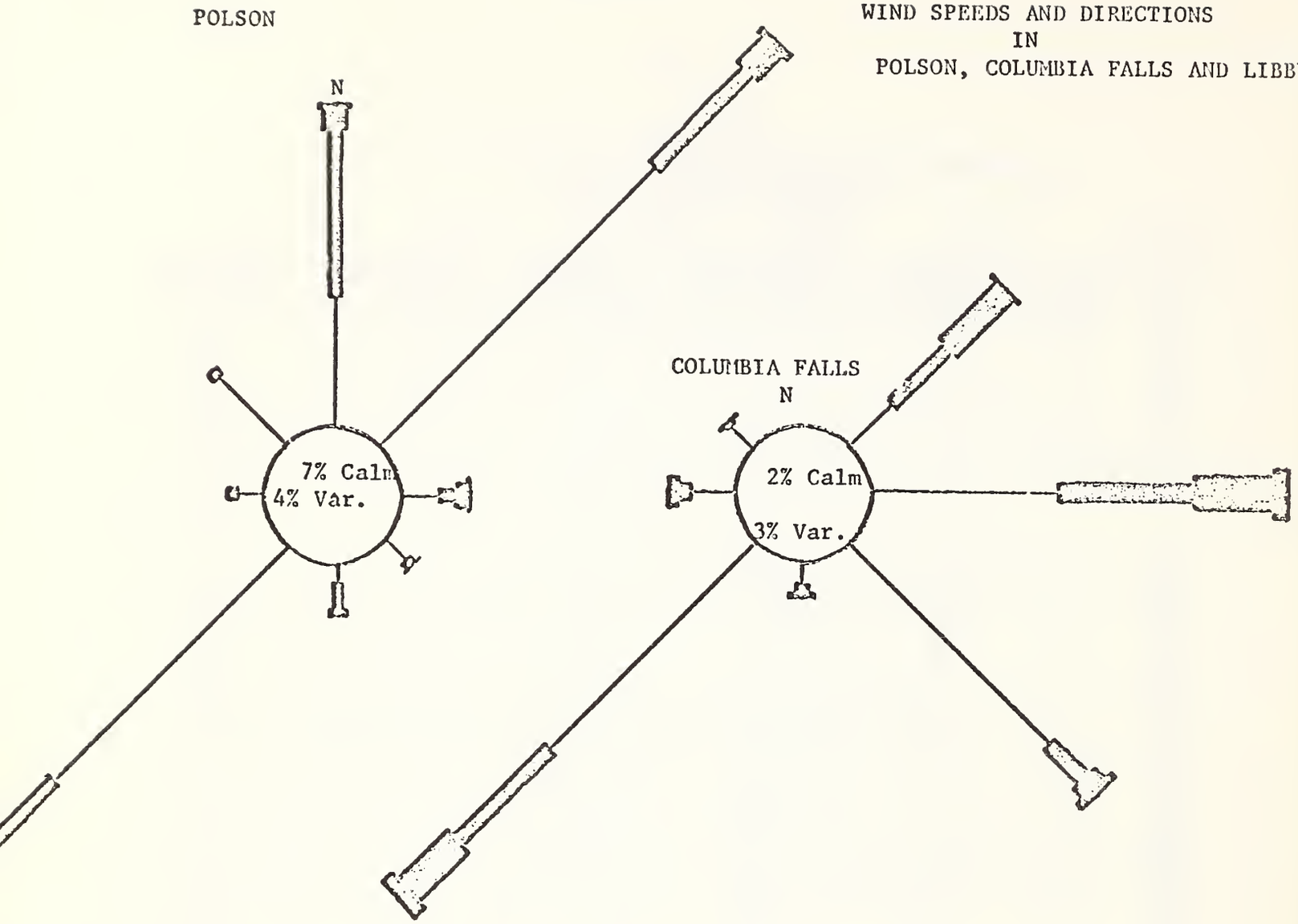
Inversions Occurring During Hours of 6 A.M. to 6 P.M.
Flathead Valley - 1963

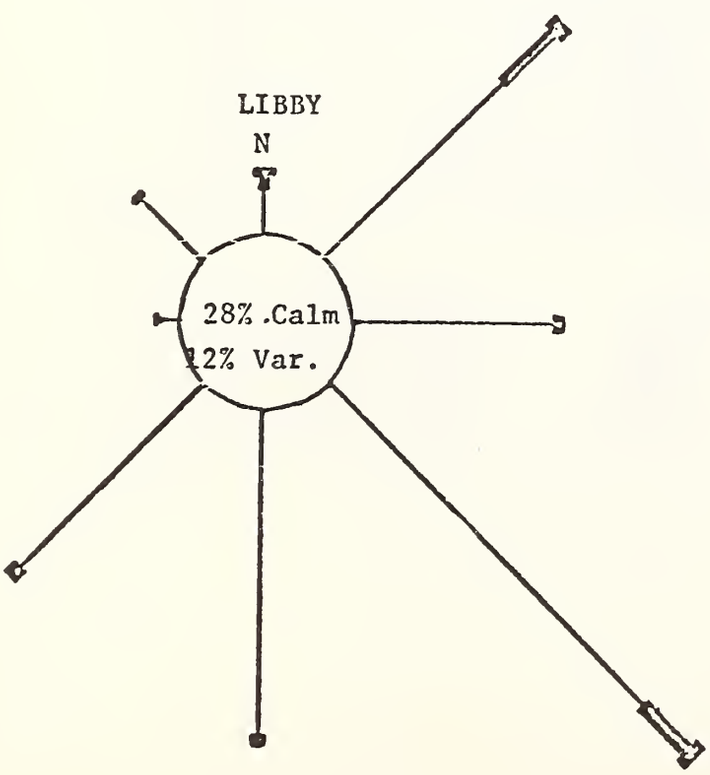
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	X			X	X	X^{s}
2		X	X	X		X^{s}
3		X	X	X	X	X^{s}
4	X	X	X	X	X	X^{s}
5	X	X	X	X		X^{s}
6	X	X	X	X		
7		X	X	X^{s}		X^{wk}
8	X	X	X	X		X
9	X	X	X^{s}	X^{s}		
10		X	X^{s}	X		
11		X		X		X^{s}
12	X	X	X	X^{s}	X	X
13	X	X		X^{s}	X	X
14	X	X	X	X	X	X
15		X	X	X		X
16	X	X	X	X^{s}		
17	X	X	X	X^{s}		
18	X	X	X^{s}	X^{s}		X
19	X	X	X^{s}	X^{s}		X
20	X	X	X	X^{s}		X
21	X	X	X		X	X^{wk}
22	X	X	X^{s}			X
23	X	X	X		X	X^{wk}
24			X			X
25		X	X			
26	X to 1000		X^{s}	$X^{v.lgt}$		X
27		X	X^{s}	X^{lgt}		X
28	X	X	X^{s}	X^{lgt}		X
29	X		X	X^{wk}	X^{s}	X
30	X		X^{s}	X^{wk}	X^{s}	X
31	X	X		X		X

X	= inversion
X^{s}	= strong inversion
X^{wk}	= weak inversion
X^{lgt}	= light inversion
$X^{v.lgt}$	= very light inversion

Figure #1

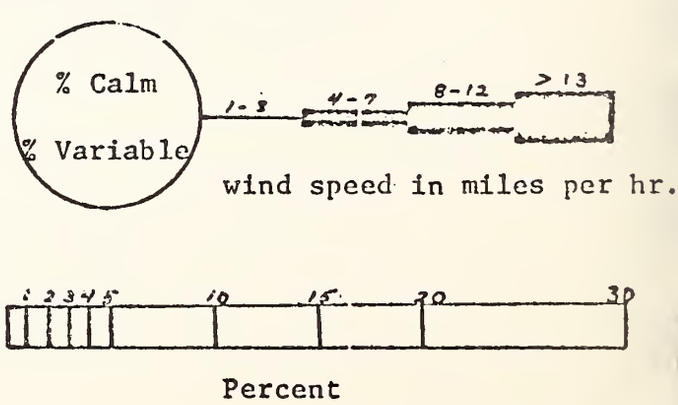
WIND SPEEDS AND DIRECTIONS
IN
POLSON, COLUMBIA FALLS AND LIBBY





FLATHEAD VALLEY WINDROSE

Length of bar equals percent of time wind blows from a given direction.
Width of bar indicates Wind speed.



COLUMBIA FALLS

Columbia Falls is a small town with a population of approximately 3,000 people, located at the north-western extreme of the Flathead Valley. It is primarily an industrial community as the site of Anaconda Aluminum Company, Plum Creek, Superior, Rocky Mountain and Stoltze Lumber Companies. The surrounding area is largely timbered to the north and west with agriculture and livestock to the south and east.

Within the town are only 7.6 miles of paved and 13.9 miles of unpaved roads.

Garbage and trash are collected and hauled to a dump site outside of the city. There is no attempt to operate it as a landfill and it has been observed to be burning during every visit to the area. Both non-essential agricultural burning and burning of trash has been observed in the surrounding area on numerous occasions. It should be noted that there is a tri-city landfill dump proposed for this area which would vastly improve this burning trash situation.

Slash burning in the surrounding mountains makes the entire Flathead Valley resemble a gigantic smudge pot during the fall. Inversions occur almost nightly with little regard to the season. During the fall and winter it is not uncommon for an inversion to last throughout the day. The inversion frequency and intensity, industrial sources present, routine open burning and lack of paved streets all contribute to the Columbia Falls area's distinction of having some of the poorest air quality in Montana.

Significant improvements in the air quality of Columbia Falls have been achieved in the past year and continued public awareness coupled with industrial endeavor should result in greater improvement in the future.

KALISPELL

The Kalispell area, with an estimated population of 18,000 contains the largest city in the Flathead Valley. It is primarily a tourist - agricultural community with several wood products companies in the area. The county seat of Flathead County, Kalispell, is located several miles north northwest of the northern shore of Flathead Lake.

There are 36 miles of paved streets and 4 miles of unpaved streets within the city limits. Garbage is picked up two times a week by a municipal service and hauled to a dump site outside of the city. Some attempt is made to landfill this site, but burning in the area has been observed. Some schools in the area and in particular West Evergreen School has been observed burning trash in open barrels on a routine basis. Open burning of trade wastes is done in violation of the regulations. Kalispell also suffers the consequences of slash burning in the surrounding mountains.

Because Kalispell's location is in a relatively open area of the Valley, it is affected by inversions of less depth and intensity than those found in the Columbia Falls area. Inversions do, however, occur on a regular basis and intensify the areas existing air pollution problems.

LIBBY

Libby is located in a low mountain valley on the west side of the Continental Divide at an elevation of 2100 feet. The Libby Valley located about 75 miles west of Columbia Falls, contains an estimated population of 7200 people in the valley area. The lumbering industry is the primary industrial endeavor in the area. There is very little farming or ranching in this area. The construction of Libby Dam has caused a relatively large influx of people into the valley over the past several years.

Winds are extremely light as shown on Figure #1. Strong inversions are frequent. This extreme atmospheric stability intensifies the air pollution problem present in the Libby Valley.

Garbage is collected in the city by commerical service and is hauled to an open dump site. Burning at the dump site is common. A proposal has been made to construct a landfill site in the near future which will help to prevent open burning of garbage and trash in the area. Open burning is also common throughout the community, which adds a great deal to the particulate loading of the local air. The abundant use of coal and oil for space heating also contributes to the sulfur dioxide and particulate loading. The major source of particulate is, however, dusty paved streets and unpaved streets. Within the city of Libby there are 20.3 miles of unpaved streets and only 1.9 miles of paved streets.

Slash burning in the area envelops the entire valley in smoke during the fall months.

POLSON

Polson, a small community of approximately 2500 people, is located on the southern tip of the Flathead Lake. It is the county seat of Lake County and is primarily engaged in tourism and agriculture. There are several wood products industries located in the surrounding area.

Within the city limits there are approximately 15 miles of paved and 5 miles of unpaved streets. Garbage is collected 2 times a week in the city but burning barrels are a standard device for disposing of trash. The dump site was purposely burned on at least one occasion to reduce the volume.

Local government has not been wholly cooperative in assistance with administering the State open burning regulations but increased awareness has become evident. Open burning throughout the county is a standard practice. Completion of a proposed landfill site and cooperation of county officials would contribute a great deal toward compliance with the State open burning regulations.

Inversions have been observed in the area often, rendering the area susceptable to a more extensive air pollution problem if a program of rigorous air quality control is not administered.

CONCLUSIONS AND RECOMMENDATIONS

FLATHEAD VALLEY

The air quality in Flathead Valley has shown an alarming decline during the past seven years. Reference to Table #6 will show that suspended particulate, sulfate fraction of the suspended particulate and sulfur dioxide levels have all increased markedly. Insufficient data is available to demonstrate the suspected increases in other pollutants measured. Comparison of selected pollutant levels in the Flathead Valley with those found in large metropolitan areas of the United States are shown on Table #3 to demonstrate the intensity of air pollution in the Flathead Valley. In general the major measured pollutants of the Flathead Valley are fluoride, suspended particulate and dustfall. During the ten year period from 1960 to 1970 the populations of Lake and Flathead Counties increased by 10% and 20% respecitvely. Motor vehicles showed an increase of 37% and 48% respectively. During the last year wood products industries have improved their methods of waste disposal, which is evident from the decreased benzene soluble fraction of the suspended particulate and smaller amounts of wood chips in dustfall samples. A significant portion of the suspended particulate is, however, still attributable to the emissions of wood waste burners. The most significant source of suspended particulates and dustfall is, however, from dusty paved and unpaved streets and open burning. Any increase in fluoride, emitted by the Anaconda Aluminum Plant in Columbia Falls, could not be substantiated due to lack of sufficient previous data. Ambient fluoride levels measured were grossly in excess of the State standard in the immediate area of the plant and decreased to occasional excessive amounts at the southern boundary of the study area.

This air quality study has led to the following recommendations:

1. That dust suppressants be applied to all unpaved city streets. Excessively dusty streets are in violation of Regulation 90-005 entitled "Preventing Particulate Matter from Becoming Airborne" - effective Nov. 23, 1968.

2. That a street cleaning program of paved streets be initiated and employed at regular intervals.

3. That all open burning be stopped. Open burning is in violation of Regulation 90-010 entitled "Open Burning Restrictions" and effective on November 23, 1968.

4. That an alternative method to slash disposal by burning be found.

5. That wood products industries increase their effort towards better combustion in wood waste burners. Excessive emission is in violation of Regulation 90-014 entitled "Prevention, Abatement and Control of Air Pollution from Wood Waste Burners" - effective June 1, 1970.

6. That the Anaconda Aluminum Company reduce emissions of fluoride to the required 864 lbs/day, as prescribed in Regulation 90-019 entitled "Maximum Allowable Emission of Fluorides from Primary Aluminum Reduction Plants, Aluminum Smelters or Aluminum Manufacturing Plants" - effective June 30, 1973.

7. That a study be conducted on hydrocarbon emissions from the Anaconda Aluminum Company.

8. That a continuing air monitoring station be maintained in the Flathead Valley.

CONCLUSIONS AND RECOMMENDATIONS

LIBBY VALLEY

The Libby Valley has an extreme air pollution problem which is intensified by the nearly total stability of the valley air. Reference to Table #13 is helpful in understanding the magnitude of Libby's problem in comparison with large metropolitan areas in the United States. In each comparison city listed, the overall dirtiness of the available air, as measured by collection of suspended particulate, is lower than that measured in Libby.

Table #4 shows an increase in population of Lincoln County of 44% during the ten year period from 1960 to 1970. The increase in motor vehicles during the same period is 88% (Table #5). Reference to Table #6 shows that there is a concurrent increase in suspended particulate levels in the air of 47%. Because there has been no known significant increase in industrial production in the area, the major share of the increased suspended particulate must be attributed to the increase in community activity. It is also notable that there has been a decrease in the benzene soluble fraction of the suspended particulate of 22%. While this decrease in benzene soluble fraction is indicative of improving conditions in local combustion practices, it is still far from acceptable.

All of the above indicates that the primary reasons for the extremely poor air quality in the Libby Valley are airborne dirt from community activity and aerosols arising from continued poor combustion practices.

As indicated by this study, the major sources of air pollutants in the Libby area are: dust and dirt from unpaved and dirty streets, smoke from the many surrounding slash fires, smoke from open burning of trash and smoke from local industry.

Libby is fortunate in that by paving or using dust suppressant on its city streets, initiating a street cleaning program and stopping all open burning it could reduce the suspended particulate loading to the surrounding air drastically. This is an ideal situation for the person who asks what he can do about pollution to demonstrate just what he can do by promoting these programs.

This air quality study has led to these recommendations:

1. That city streets be paved or treated with dust suppressant materials. Excessively dusty streets are in violation of Regulation 90-005 entitled "Preventing Particulate Matter from Becoming Air-Borne" - effective November 23, 1968.

2. That paved streets be cleaned at reasonable intervals.

3. That all open burning be stopped. Open burning is in violation of Regulation 90-010 entitled "Open Burning Restrictions" - effective on November 23, 1968.

4. That an alternative method to slash disposal by burning be found.

5. That a continuing air monitoring station be maintained in Libby.

A complete air monitoring station
in the Libby Area.

TABLE #3

Comparison of Selected Pollutant Levels
in the Flathead and Libby Valleys with those
found in various cities

City	Year	Suspended Particulate	Benzene Sol. Fraction	Sulfate Fraction	Sulfur Dioxide	Dustfall
Chicago	1966	195 ug/m^3	18.0 ug/m^3	14.2 ug/m^3	3.2 $mg/100\ cm^2/day$	67.1 $Tons/mi^2/mo.$
Cinn.	1966	154 ug/m^3	7.9 ug/m^3	13.1 ug/m^3	0.7 $mg/100\ cm^2/day$	22.9 $Tons/mi^2/mo.$
L.A.	1966	119 ug/m^3	15.2 ug/m^3	14.4 ug/m^3	0.3 $mg/100\ cm^2/day$	7.7 $Tons/mi^2/mo.$
N.Y. City	1966	134 ug/m^3	10.3 ug/m^3	28.8 ug/m^3	2.0 $mg/100\ cm^2/day$	10.8 $Tons/mi^2/mo.$
Portland	1966	75 ug/m^3	6.1 ug/m^3	11.5 ug/m^3	0.7 $mg/100\ cm^2/day$	47.7 $Tons/mi^2/mo.$
Col. Falls	1969	124 ug/m^3	9.5 ug/m^3	3.0 ug/m^3	0.05 $mg/100\ cm^2/day$	30.4 $Tons/mi^2/mo.$
Kalispell	1969	87 ug/m^3	6.4 ug/m^3	2.6 ug/m^3	0.05 $mg/100\ cm^2/day$	14.3 $Tons/mi^2/mo.$
Libby	1969	243 ug/m^3	21.3 ug/m^3	3.9 ug/m^3	0.06 $mg/100\ cm^2/day$	21.2 $Tons/mi^2/mo.$
Polson	1969	71 ug/m^3	6.9 ug/m^3	2.4 ug/m^3	0.03 $mg/100\ cm^2/day$	10.1 $Tons/mi^2/mo.$

TABLE #4

COMPARISON OF COUNTY POPULATION LEVELS IN 1960 AND 1970

County	Population 1960	Population 1970	% Increase
Flathead	32,965	39,460	20%
Lake	13,104	14,445	10%
Lincoln	12,537	18,063	44%

TABLE #5

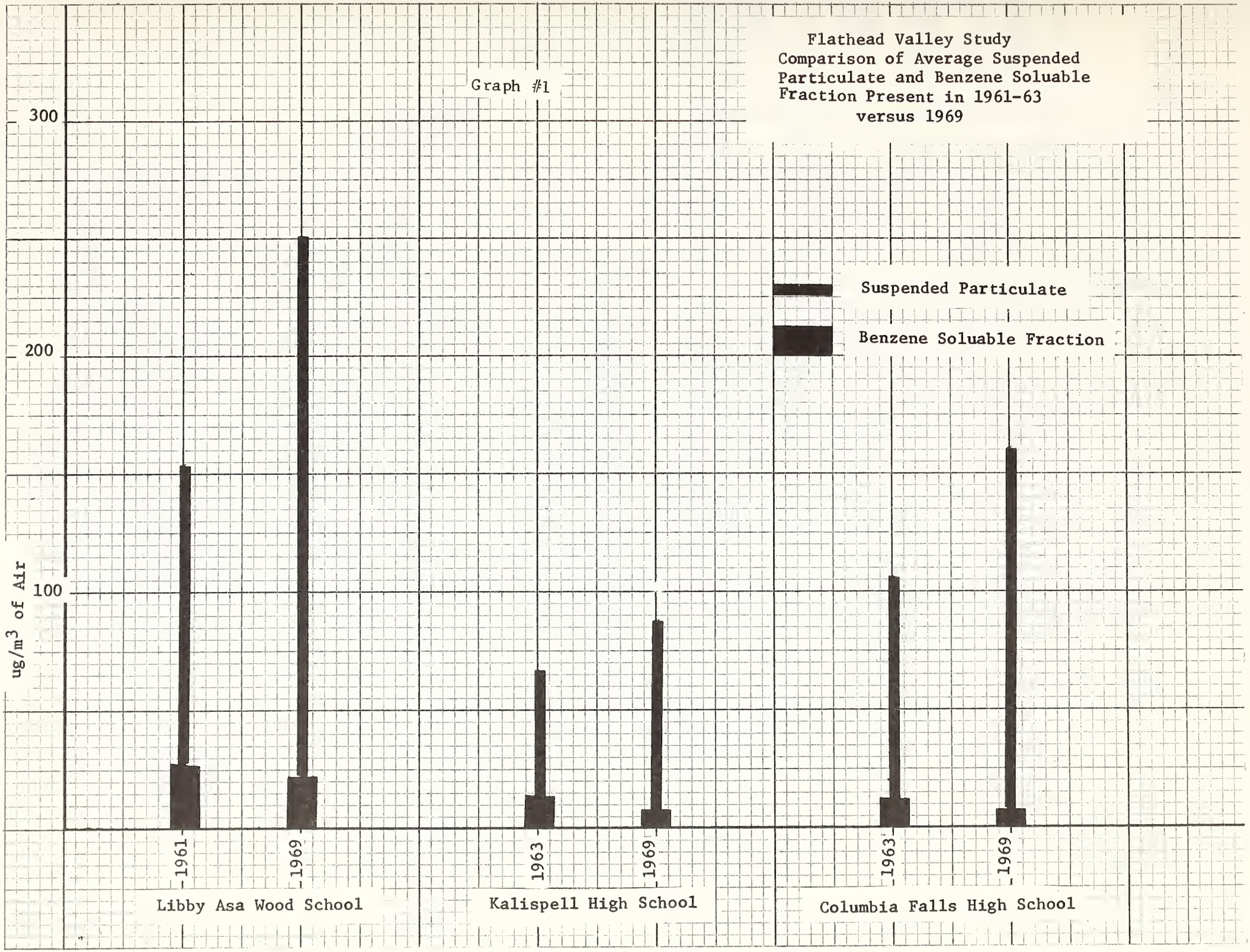
COMPARISON OF REGISTERED VEHICLES IN 1960 AND 1970

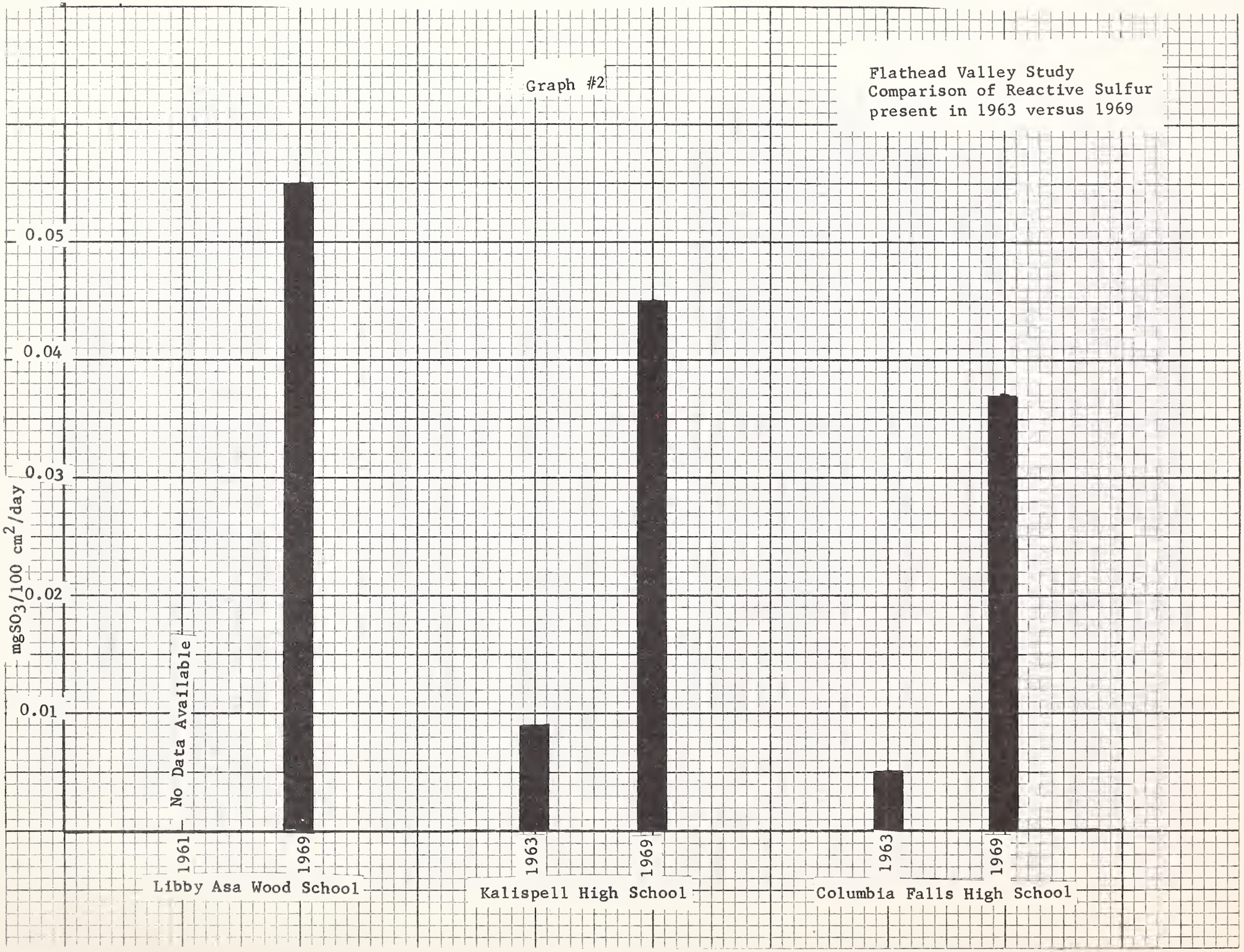
County	Registered Veh. 1960	Registered Veh. 1970	% Increase
Flathead	18,202	26,979	48%
Lake	7,267	9,951	37%
Lincoln	6,229	11,713	88%

TABLE #6

COMPARISON OF AVERAGE STUDY AREA POLLUTANT CONCENTRATIONS WITH PREVIOUS STUDY FINDINGS

City	Pollutant	Date	Concentration	1969-70 concentration	% Inc.	% Dec.
Col. Falls	Susp. Part.	1963-64	104 ug/m^3	151 ug/m^3	31%	
Kalispell	"	"	65 "	87 "	25%	
Libby	"	1961-62	128 "	243 "	47%	
Col. Falls	Benzene Sol. Fraction	1963-64	11.8 "	9.4 "		20%
Kalispell	"	"	10.8 "	6.3 "		45%
Libby	"	1961-62	27.4 "	21.3 "		22%
Col. Falls	Sulfate	1963-64	0.75 "	1.80 "	58%	
Kalispell	"	"	1.07 "	2.30 "	58%	
Col. Falls	Sulfur Dioxide	1963-64	0.005 $mg/100cm^2/day$	0.37 $mg/100cm^2$ per day	86%	
Kalispell	"	"	0.009 "	0.045 $mg/100cm^2$ per day	80%	


Graph #1
Flathead Valley Study
Comparison of Average Suspended
Particulate and Benzene Soluable
Fraction Present in 1961-63
versus 1969
Suspended Particulate
Benzene Soluable Fraction
300
200
100
ug/m3 of Air
1961
1969
1963
1969
1963
1969
Libby Asa Wood School
Kalispell High School
Columbia Falls High School


Graph #2
Flathead Valley Study
Comparison of Reactive Sulfur
present in 1963 versus 1969
mgSO3/100 cm2/day
0.05
0.04
0.03
0.02
0.01
No Data Available
1961
1969
1963
1969
1963
1969
Libby Asa Wood School
Kalispell High School
Columbia Falls High School

AN ECONOMICAL METHOD FOR DUST SUPPRESSION ON UNPAVED CITY STREETS

Economical and effective methods of dust suppression have been developed which should be valuable in controlling dust in communities unable to surface their streets with asphalt. The following is a portion of a paper written by Leonard J. Stern, Engineer in Charge, Arcadia Materials Testing Laboratory, U. S. Forest Service.

"Our objectives were to develop a product that would satisfy the following requirements:

1. To be less expensive than watering
2. To make the road surface dust free
3. To reduce shifting and loss of road metal
4. To hold potholding to a bare minimum
5. To develop a fairly smooth riding surface that would permit maximum utilization of the designed speeds
6. To provide a rebladable surface as wear developed
7. To have a high percentage of oil salvage from winter weathering

Quantity Required -- The quantity of dust oil required will vary with the soil type, road condition, and amount and type of traffic. For a stable roadbed in a soil which will bind with water, an application of 1/2 gal. per sq. yd. will usually be adequate for the first treatment. On soils for which the oil requirements are abnormally high (as for very sandy soils or some soils of volcanic origin), the requirement may be as high as 3/4 gal. or 1 gal. per sq. yd. and under certain conditions satisfactory results have not been obtainable up to the time this article was written.

Application -- The dust oil has been designed for the following method of application:

1. Grade, water, shape, and compact the roadbed, importing metal if necessary to get a satisfactory traveling surface.
2. Allow this surface to dry out a maximum moisture content of 5% in the top two inches and to develop a maximum of 1/8 inch of loose material. If this does not develop naturally through traffic, sufficient scarifying and blading should be done to get this absorbent pad. The dust oil will not penetrate a hard, glazed surface. However, in scarifying, care must be taken to avoid developing too much loose material, as this will then absorb the oil and penetration will be impossible.

3. Apply the dust oil at the rate of 1/2 gal. per sq. yd. in two 1/4 gal. applications. The second application should follow immediately after the first shot has penetrated. The time will vary from 10 minutes to one hour, depending upon varying soil conditions and temperatures. In rare cases the 1/2 gal. per sq. yd. must be made in three applications if the road surface is not absorbant.

The road need not be taken out of service during the application. No equipment of any type is required at the time of application except the oil distributor. A pilot car sufficiently ahead of the oil truck to clear traffic is all that is required. Traffic may resume immediately if necessary, but a waiting period of 15 to 20 minutes is recommended to avoid danger of accidents since some spots may be slippery immediately after spraying.

A vehicle traveling the freshly treated road will pick up some of the lubricating oil fraction on its tires. This will build up, then be redeposited on the wheel track, resulting in no permanent harm to the road surface. However, to achieve the best results it is recommended that the application be made over a weekend. There is no additional charge by the oil companies for oiling on Saturdays and Sundays.

Cost of Application -- In most areas in Northern and Central California our recent bid prices reflect a cost of less than 17¢ per gallon delivered and spread on the roadway. An initial application on a 12-foot roadway at 1/2 gallon per square yard will require 3500 gallons, and a 20-foot roadway, 5900 gallons per mile, respectively. Cost per mile would be $595 for the 12-foot roadway. An additional 1/4 gallon per square yard application is normally recommended the first year after traffic has used the road for four to six weeks. Cost of this application is one-half of the above application.

Life of the Material -- The life of the material will depend on the soil type, the condition of the subgrade, the condition of the surface at the time of application, the weight and frequency of the loads, and the climatic conditions. Under normal conditions the application of 1/2 to 3/4 gal. per sq. yd. should insure dust-free operation during the logging season, with the road metal showing ravel late in the season. Sharp curves will break out and some soft spots will develop. A spotting of these areas will improve traffic conditions. If the subgrade is unstable and subject to winter rutting, if crawler-tractors are moved over the road in late fall and if the road is subject to considerable sliding, little will remain of the dust oil after going through a winter. On the other hand, if the roadbed is essentially stable and a late season application of the dust oil has been made, the winter carry-over may be considerable and the roadbed will have maximum protection from the longitudinal wash. Then preceding the next year's dust season, an application of 1/4 gal. per sq. yd. should be applied.

Maintenance Requirements -- No blading or other maintenance should be done during the satisfactory life of the dust oil. When and if raveling becomes acute, the road or raveled portions should be reshaped and a further application of 1/4 gal. per sq. yd. applied. Where the roadbed is stable, reshaping and a light application just before the winter rains will be beneficial in saving the road metal and reducing erosion losses.

Water cannot be effectively applied to a road surface treated with dust oil until such time as the dust oil has been removed by traffic or the weather."

Dust suppressive oil such as this has been used by the community of Three Forks with a great deal of success. Residents were so pleased by the effect of using such oil on the avenues that they donated funds to have the streets treated.

Effective dust suppression is within the means of virtually every Montana community.

DESCRIPTION OF AIR QUALITY MEASUREMENTS

There were more than 4000 air quality measurements made during this study period. These included 246 fluoride in the air samples, 31 reactive sulfur determinations, 226 dustfall collections, 124 fluoride in vegetation analyses and 1130 high volume filter samples which were subjected to total particulate, benzene soluble fraction, sulfate, arsenic and lead analysis. In addition, continuous wind speed and direction data was collected at three meteorological sites during the study period. Following is a short summary of the types of determinations made and the air quality standards that apply.

Dustfall - or settled particulate is a measure of the larger particles which tend to settle out of the atmosphere. An open mouthed container is set in an exposed location and allowed to collect fallout from the atmosphere for a period of approximately one month. The collected matter is then weighed and the total amount that would have fallen on one square mile under the same conditions is calculated. The State Ambient Air Quality Standard for settled particulate is 15 tons per square mile per month, three months average in residential areas and 30 tons per square mile, three month average in heavy industrial areas.

Reactive Sulfur - or sulfation rate is a gross measure of the sulfur oxides, primarily sulfur dioxide. It is measured over a monthly period by exposing a chemically treated surface to the ambient air and weighing the resulting reaction products at the end of the exposure period. The State Ambient Air Quality Standard for reactive sulfur is 0.25 milligrams sulfur trioxide per 100 square centimeters per day, maximum annual average; 0.5 milligrams sulfur trioxide per 100 square centimeters per day, maximum for any one month period.

Total Suspended Particulate Matter - is an air pollutant consisting of finely divided particles too small to settle out rapidly and small enough to be drawn into the lungs where some of the particles will be retained. This particulate is collected in a high volume sampler, which is a device which draws a high volume of air through a filter paper for a period of approximately 24 hours collecting the fine particles. The filter paper is weighed both before and after the collection period giving the weight in micrograms of trapped particles per cubic meter of air sampled. The Ambient Air Quality Standard for total suspended particulate is 75 micrograms per cubic meter of air annual geometric mean in 200 micrograms per cubic meter of air not to be exceeded more than 1% of the days of a year.

After the weight of the suspended particulate is determined, the filter paper can then be used for more specific tests for other air pollutants.

Benzene Soluble Fraction - One-half of the high volume filter is used for determination of the benzene soluble fraction. This portion of the filter paper is distilled in benzene and the resulting quantity of the benzene soluble fraction is an indication of the organic material present in the suspended particulate. It is sometimes useful to relate the benzene soluble fraction and the particulate fraction by calculating the percentage benzene soluble versus particulate. There is no State standard for benzene soluble fraction.

Lead - is a measurement of the amount of lead in the air determined from a portion of the high volume filter. The State standard for lead in the air is 5 micrograms per cubic meter of air, 30 days average.

Arsenic - an analysis of arsenic in the air also determined from a fraction of the filter paper. There is no State standard for arsenic in the air at the present time.

Fluoride - Fluorides are measured as total fluorides in the air, fluorides in forage for animal consumption and gaseous fluorides.

1. Total fluorides are measured by use of a continuous analyzer utilizing a colorometric determination of fluoride as HF. The State Ambient Air Quality Standard for fluoride in the air is 1 part per billion parts of air, 24 hour average.

2. Fluorides in forage for animal consumption is determined by cutting, drying, ashing and subjecting forage materials to Winter Willard distillation procedures and Spadn's Colormetric procedure. The standard for fluoride in forage is 35 parts per million.

3. Gaseous fluorides are determined by exposure of a pre-treated filter paper in a protective housing for approximately 30 days. The reaction products are then determined in the laboratory by Winter Willard distillation and reported as micrograms per centimeter squared per 28 days. The State Ambient Air Quality Standard for gaseous fluoride is 0.3 micrograms per square centimeter per 28 days.

FLUORIDE IN THE AIR - COLUMBIA FALLS

Fluoride in the air as measured by the calcium formate paper method is an indicator of the monthly average concentration of fluoride expressed as micrograms of fluoride per centimeter squared per twenty-eight days. The State Ambient Air Quality Standard calls for not more than 0.3 $ug/cm^2/28$ days.

Monthly measurements of fluoride concentrations in and around Columbia Falls were grossly in excess of the State standard. The location of sampling sites are shown in Map #II and the fluoride concentrations are listed in Table #7. Graphs #3, #4, and #5 show these monthly fluoride in air levels and their relationship to the State standard.

Of the 125 samples collected in this area only 17 were at or below the State standard. Comparisons of Graphs #3, #4, and #5 show that a high concentration of fluoride in one part of the Valley results in higher concentrations in other parts of the Valley. This indicates that there are not just high fluoride values downwind from the Anaconda Aluminum Company plant, but that there are periods of fumagation during which the entire area is exposed to excessive fluoride. A primary cause of this situation is the presence of light and extremely variable eddy winds during heavy inversion conditions. Reference to Graphs #6 and #7 show the large area of fumagation, reaching into Glacier National Park to the northeast, Polson to the south and Swan Lake to the southeast. It is apparent that during these periods of fumagation elevated levels of fluoride are not restricted to the vicinity of the aluminum plant or even to the Flathead Valley itself.

Wind direction and distance from the plant do play a significant role in distribution of fluoride emissions when averaged over the entire study period. The wind rose imposed over the Anaconda Aluminum plant and average concentrations listed at the various sampling sites show that downwind stations received larger doses of fluoride on the average for the duration of the study period.

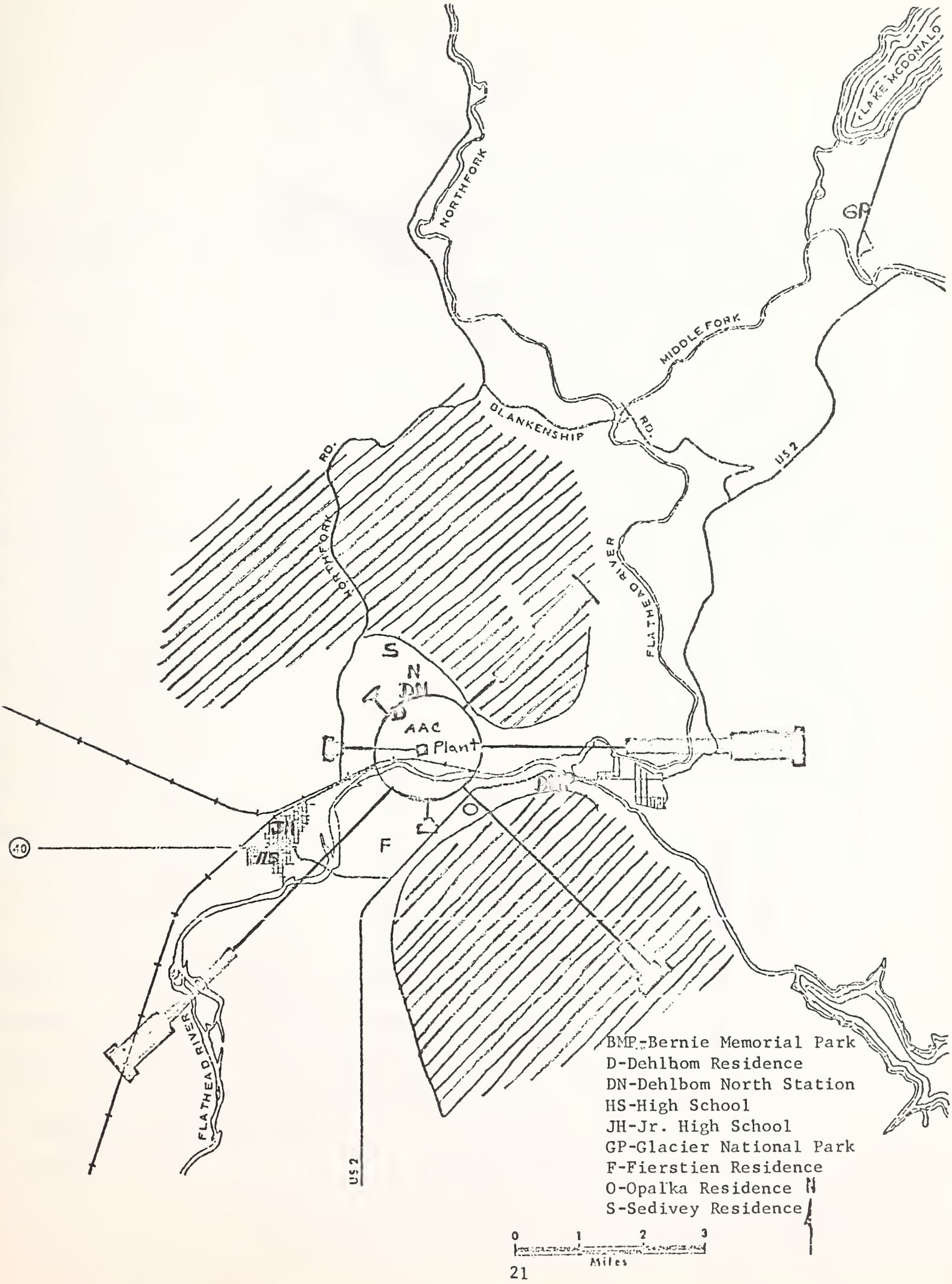
The peak registered for December, 1969, was probably affected by an eight hour shut-down of all fluoride scrubbers on November 11, 1969.

FLUORIDE IN THE AIR - KALISPELL, LIBBY, AND POLSON

Graph #6 and Table #8 show the fluoride in the air concentrations in Kalispell, Libby, and Polson. Map III shows sampling site locations.

As shown, Libby does not show significant fluoride levels. All values are well below the State Ambient Air Quality Standard. Kalispell and Polson also have mabient fluoride levels which are generally below the State Ambient Air Quality Standard. It is, however, extremely interesting that elevation of fluoride levels occur during intervals of fumagation by the Anaconda Aluminum Company plant. This situation demonstrates the susceptability of the entire Flathead Valley to dangerous episodes of extreme air pollution.

MAP II
Fluoride-in-Air Sampling Sites



MAP #III

LIBBY VALLEY STUDY AREA

Complete Station includes:
- High Volume Sampler
- Dustfall
- Fluoride Paper
- Sulfur Dioxide Plate

Complete Station plus meteorological station

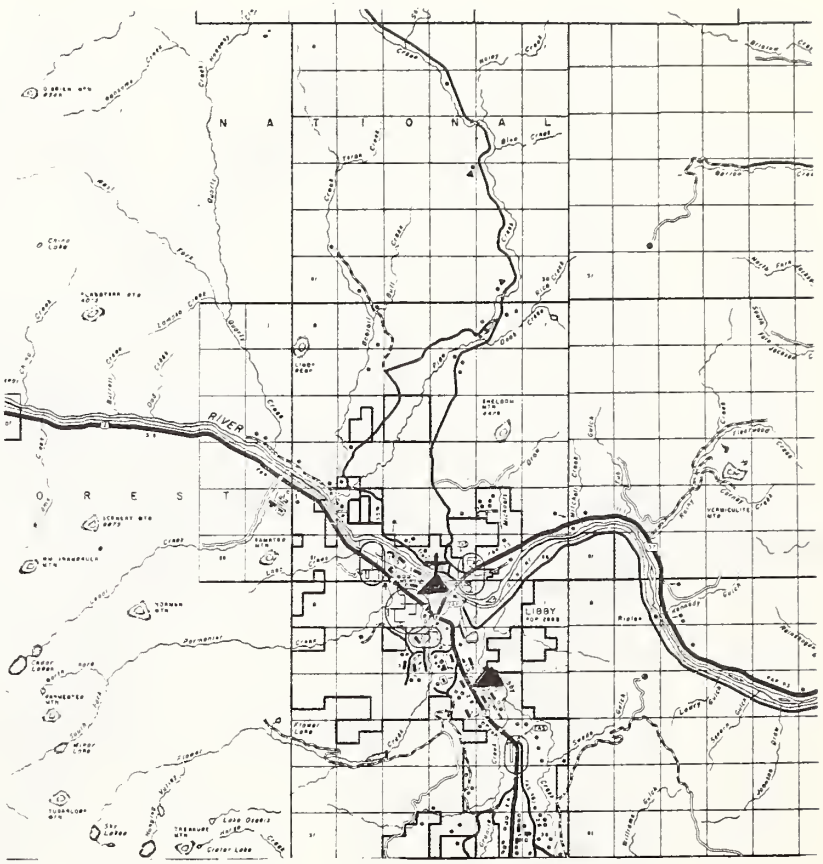


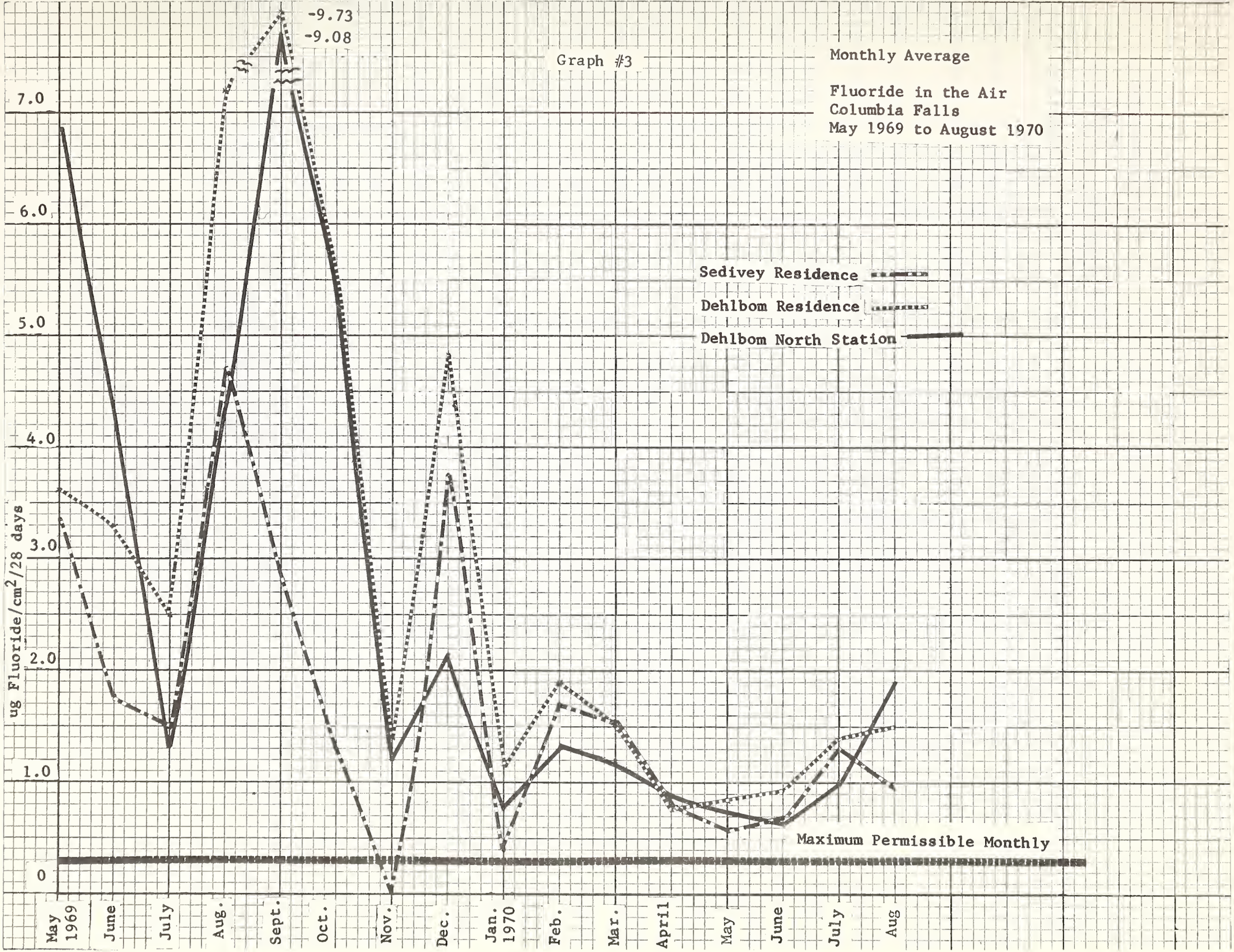
TABLE #7

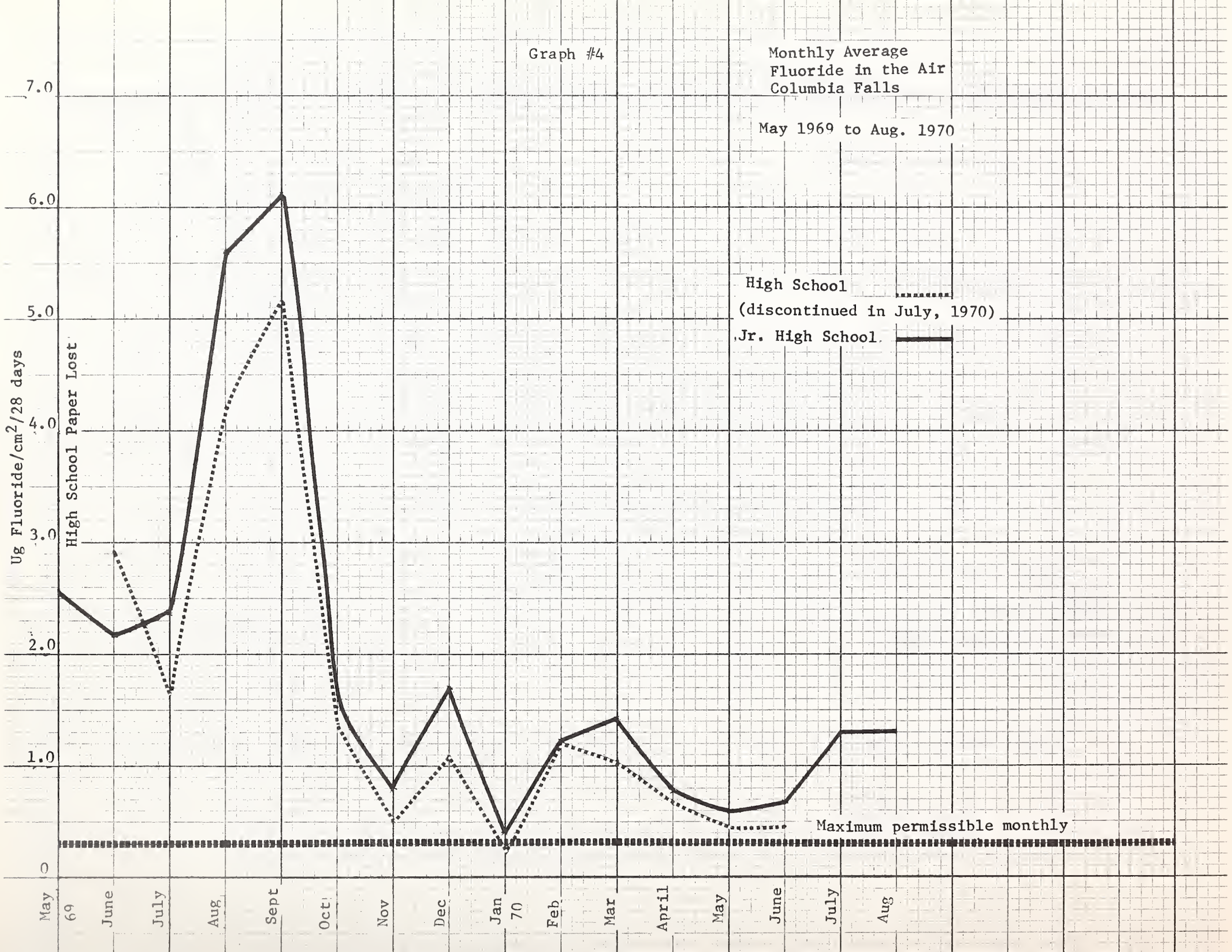
Fluoride In Air
COLUMBIA FALLS
(calcium formate paper)
ug/cm^2/28 days

Date of Collection	B.M.P.	Dehlboms Res.	Dehlboms N. Sta.	High School	Jr. High School	Feirstein Res.	Opalka Res.	Sedivey Res.
May 1969	0.45	6.85	3.61	---	2.58	1.19	0.18	3.35
June 1969	0.37	4.30	3.30	2.91	2.18	2.10	0.69	1.78
July 1969	1.00	1.30	2.50	1.65	2.37	0.58	0.18	1.50
Aug. 1969	1.40	4.40	7.20	4.20	5.60	3.10	1.00	4.70
Sept. 1969	1.18	9.08	9.73	5.15	6.11	2.81	2.28	2.81
Oct. 1969	0.77	5.41	5.41	1.39	1.52	1.26	0.86	1.13
Nov. 1969	1.00	1.20	1.40	0.50	0.80	0.20	0.04	*N.D.
Dec. 1969	3.78	2.14	4.83	1.09	1.70	1.70	1.70	3.75
Jan. 1970	1.20	0.78	1.18	0.24	0.40	0.24	0.23	0.40
Feb. 1970	4.80	1.30	1.90	1.20	1.20	1.20	0.23	1.70
Mar. 1970	1.95	1.20	1.54	1.03	1.41	0.99	0.21	1.54
Apr. 1970	0.43	0.87	0.79	0.66	0.79	0.61	0.18	0.81
May 1970	0.24	0.73	0.84	0.45	0.59	0.43	0.10	0.59
June 1970	0.56	0.65	0.93	0.46	0.69	0.46	0.08	0.69
July 1970	0.44	1.40	1.00	Dis-continued	1.30	0.74	0.19	1.30
Aug. 1970	0.23	1.50	1.90		1.30	0.92	0.16	0.97
Average	1.24	2.69	3.00	1.61	1.90	1.16	0.52	1.80
Maximum	4.80	9.08	9.73	5.15	6.11	3.10	2.28	4.70
Minimum	0.23	0.65	0.79	0.24	0.40	0.20	0.04	*N.D.

Standard 0.3 ug/cm^2/28 days

* None detected.


Graph #3
Monthly Average
Fluoride in the Air
Columbia Falls
May 1969 to August 1970
-9.73
-9.08
Sedivey Residence
Dehlbom Residence
Dehlbom North Station
Maximum Permissible Monthly
ug Fluoride/cm2/28 days
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
May 1969
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan. 1970
Feb.
Mar.
April
May
June
July
Aug


Graph #4
Monthly Average
Fluoride in the Air
Columbia Falls
May 1969 to Aug. 1970
High School
(discontinued in July, 1970)
Jr. High School
Maximum permissible monthly
High School Paper Lost
Ug Fluoride/cm2/28 days
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
May 69
June
July
Aug
Sept
Oct
Nov
Dec
Jan 70
Feb
Mar
April
May
June
July
Aug

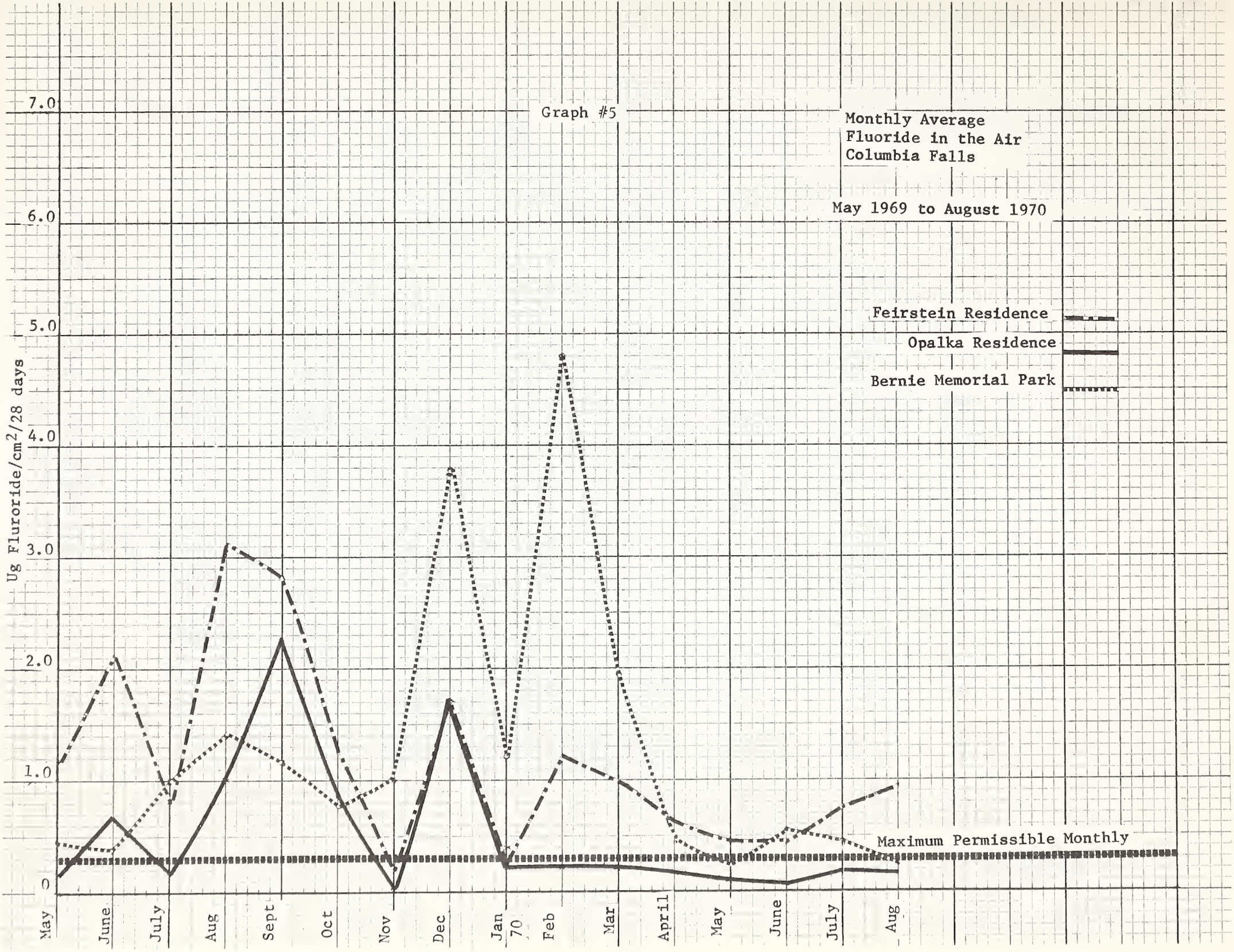

Graph #5
Monthly Average
Fluoride in the Air
Columbia Falls
May 1969 to August 1970
Feirstein Residence
Opalka Residence
Bernie Memorial Park
Maximum Permissible Monthly
Ug Fluoride/cm2/28 days
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan 70
Feb
Mar
April
May
June
July
Aug

TABLE #8

Fluoride In The Air

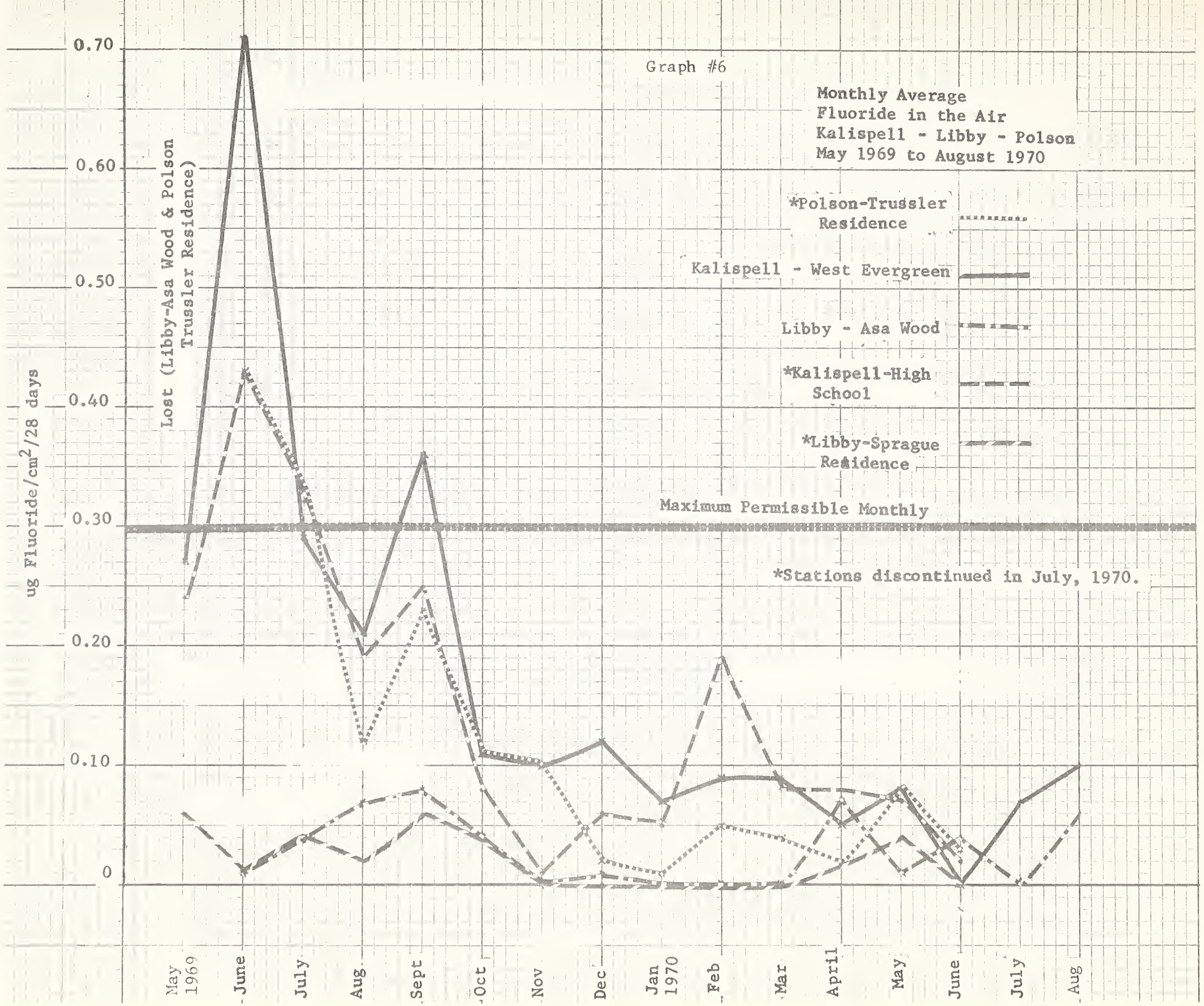
(Calcium Formate Paper)

ug/cm^2/28 days

Date of Collection	Kalispell		Libby		Polson
	High School	West Evergreen	Asa Wood	Sprague's	Trusslers
May, 1969	0.24	0.27	Lost	0.06	Lost
June, 1969	0.43	0.71	0.01	0.01	0.43
July, 1969	0.32	0.29	0.04	0.04	0.33
Aug., 1969	0.19	0.21	0.07	0.02	0.12
Sept., 1969	0.25	0.36	0.08	0.06	0.23
Oct., 1969	0.08	0.11	0.04	0.04	0.11
Nov., 1969	0.01	0.10	*N.D.	*N.D.	0.10
Dec., 1969	0.06	0.12	0.01	*N.D.	0.02
Jan., 1970	0.05	0.07	*N.D.	*N.D.	0.01
Feb., 1970	0.19	0.09	*N.D.	*N.D.	0.05
Mar., 1970	0.08	0.09	*N.D.	*N.D.	0.04
April, 1970	0.08	0.05	0.07	0.02	0.02
May, 1970	0.07	0.08	0.01	0.04	0.08
June, 1970	0.02	*N.D.	0.04	*N.D.	0.03
July, 1970	Dis-continued	0.07	*N.D.	Dis-continued	Dis-continued
Average	0.15	0.19	0.04	0.04	0.12
Maximum	0.43	0.71	0.08	0.06	0.43
Minimum	0.01	*N.D.	*N.D.	*N.D.	0.01

Standard 0.3 ug/cm^2/28 days

*None Detected


Graph #6
Monthly Average
Fluoride in the Air
Kalispell - Libby - Polson
May 1969 to August 1970
*Polson-Trussler Residence
Kalispell - West Evergreen
Libby - Asa Wood
*Kalispell-High School
*Libby-Sprague Residence
Maximum Permissible Monthly
*Stations discontinued in July, 1970.
ug Fluoride/cm2/28 days
Lost (Libby-Asa Wood & Polson Trussler Residence)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
May 1969
June
July
Aug
Sept
Oct
Nov
Dec
Jan 1970
Feb
Mar
April
May
June
July
Aug

FLUORIDE IN AIR - GLACIER NATIONAL PARK

Monthly sampling of fluoride in the air was done at the Glacier National Park fire-weather station during the Flathead Valley study. The location of this sampling site is shown on Map #II. Fluoride in the air values are listed on Table #9 and their relationship to the State standard is shown on Graph #7.

As shown on Graph #7 the State Ambient Air Quality Standard was exceeded at Glacier Park Station in seven of the 14 samples taken. Periods of extensive fluoride fumagation also show up as peaks on this graph. Although the fluoride levels are not extremely high, damage to susceptable vegetation has been observed when the 0.3 $ug/cm^2/28$ days standard is barely exceeded.

A thorough study of the effects of fluoride in Glacier Park has been done by the National Air Pollution Control Administration during 1970 and should be completed in January of 1971.

Serious fluoride damage to a pine tree.

FLUORIDE IN THE AIR - SWAN LAKE AND EAST SHORE OF FLATHEAD LAKE

The locations of these sampling stations are shown on Map #I. Values for fluoride in the air are listed in Table #9 and their relationships to the State standard are shown on Graph #7.

It was originally thought that the fluoride emitted at the Columbia Falls plant followed the east shore of the Flathead Lake during periods of fumagation.

This data indicates that most of the fluoride diffusing along Columbia mountain turns and goes up the Swan Valley. While another pathway leads down the Flathead Valley, across the Lake and meeting the east shore of Flathead Lake about 12 miles north of Polson.

It also shows the extremely large area affected by the fumagation situations.

TABLE #9

Fluoride In Air

(calcium formate paper)

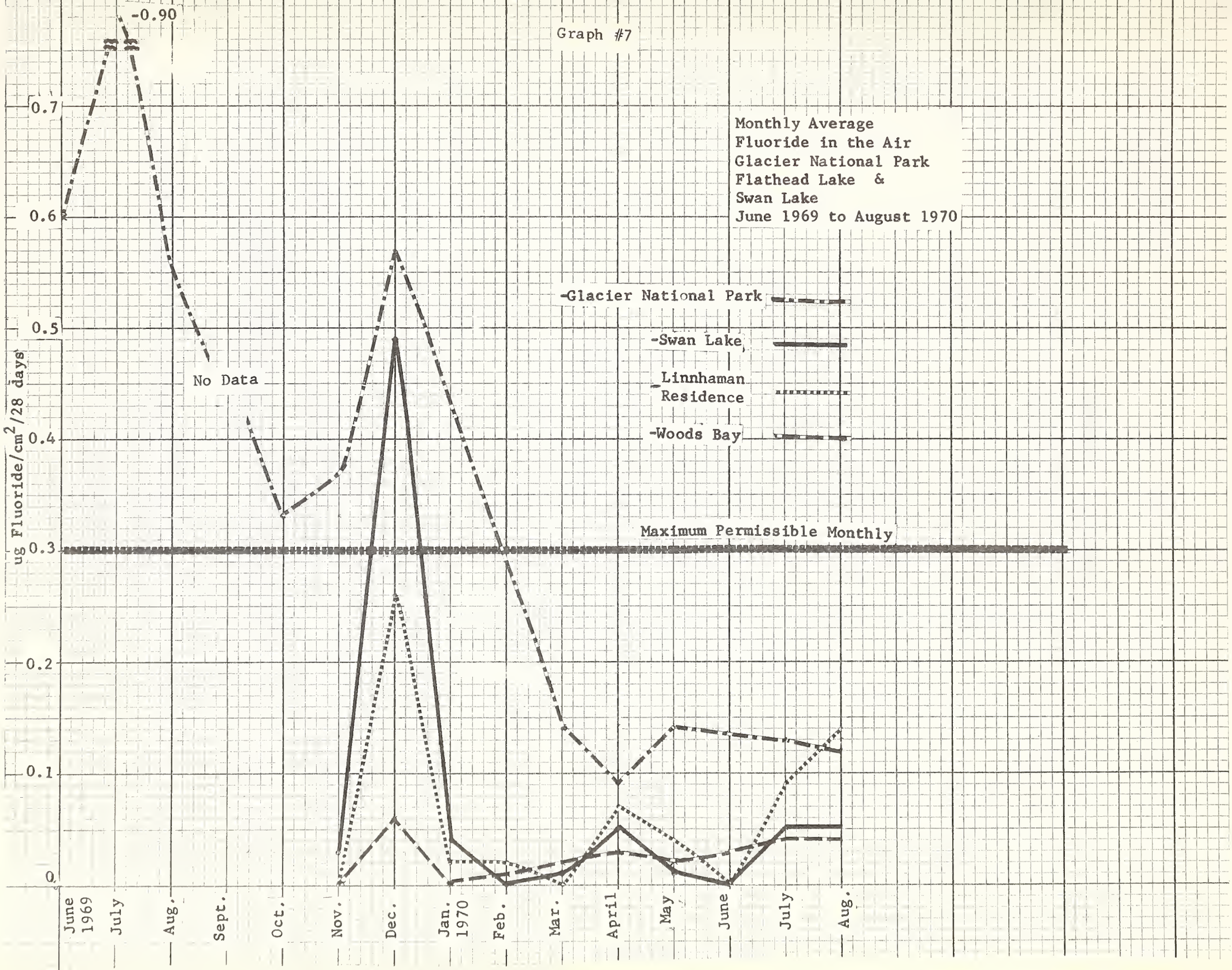
$ug/cm^2/28$ days

Date of Collection	Glacier Nat'l Park	Flathead Lake		Swan Lake
	West Glacier	Linnemans Res.	Woods Bay	
June, 1969	0.60			
July, 1969	0.90			
Aug., 1969	0.55			
Sept., 1969	No Data			
Oct. 1969	0.33			
Nov., 1969	0.37	N.D.*	N.D.*	0.30
Dec., 1969	0.57	0.26	0.06	0.49
Jan., 1970		0.02	N.D.*	0.04
Feb., 1970	**0.29	0.02	0.01	N.D.*
Mar., 1970	0.14	N.D.*	0.02	0.01
April, 1970	0.09	0.07	0.03	0.05
May, 1970	0.14	0.04	0.02	0.01
June, 1970		N.D.*	0.03	N.D.*
July, 1970	**0.13	0.09	0.04	0.05
Aug., 1970	0.12	0.14	0.04	0.05
Average	0.35	0.09	0.03	0.13
Maximum	0.90	0.26	0.06	0.49
Minimum	0.09	*N.D.	*N.D.	*N.D.

Standard $0.3ug/cm^2/28$ days

*None detected

**Two Month Exposure


Graph #7
Monthly Average
Fluoride in the Air
Glacier National Park
Flathead Lake &
Swan Lake
June 1969 to August 1970
-Glacier National Park
-Swan Lake
-Linnhaman Residence
-Woods Bay
Maximum Permissible Monthly
-0.90
No Data
ug Fluoride/cm²/28 days
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
June 1969
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan. 1970
Feb.
Mar.
April
May
June
July
Aug.

VEGETATION SURVEY OF THE COLUMBIA FALLS AREA

Grass:

During the study five grass sampling plots were designated and grass samples were collected monthly. At some sites grass was unavailable during the winter months because of heavy snow cover. The Ambient Air Quality Standard limits the amount of fluoride in forage to 35 parts per million.

Analysis for fluoride in forage collected during the study period indicates levels, on numerous occasions, above the safe limit set by the State Board of Health. Table #10 and Graph #8 show the monthly fluoride concentrations measured at the five sampling plots. Map #IV indicates the location of these plots in relation to the Anaconda Aluminum plant.

The values found during this sampling period are typical of the findings in Garrison and in previous sampling in the Columbia Falls area. That is, that the values decrease with increasing distance from the plant, that values are low during the lush growing season and rise to high in winter and that high concentrations of fluoride in the air show up as an increase in fluoride in plant tissues.

Fluoride damaged apple leaves
in the Columbia Falls Area.

TABLE #10

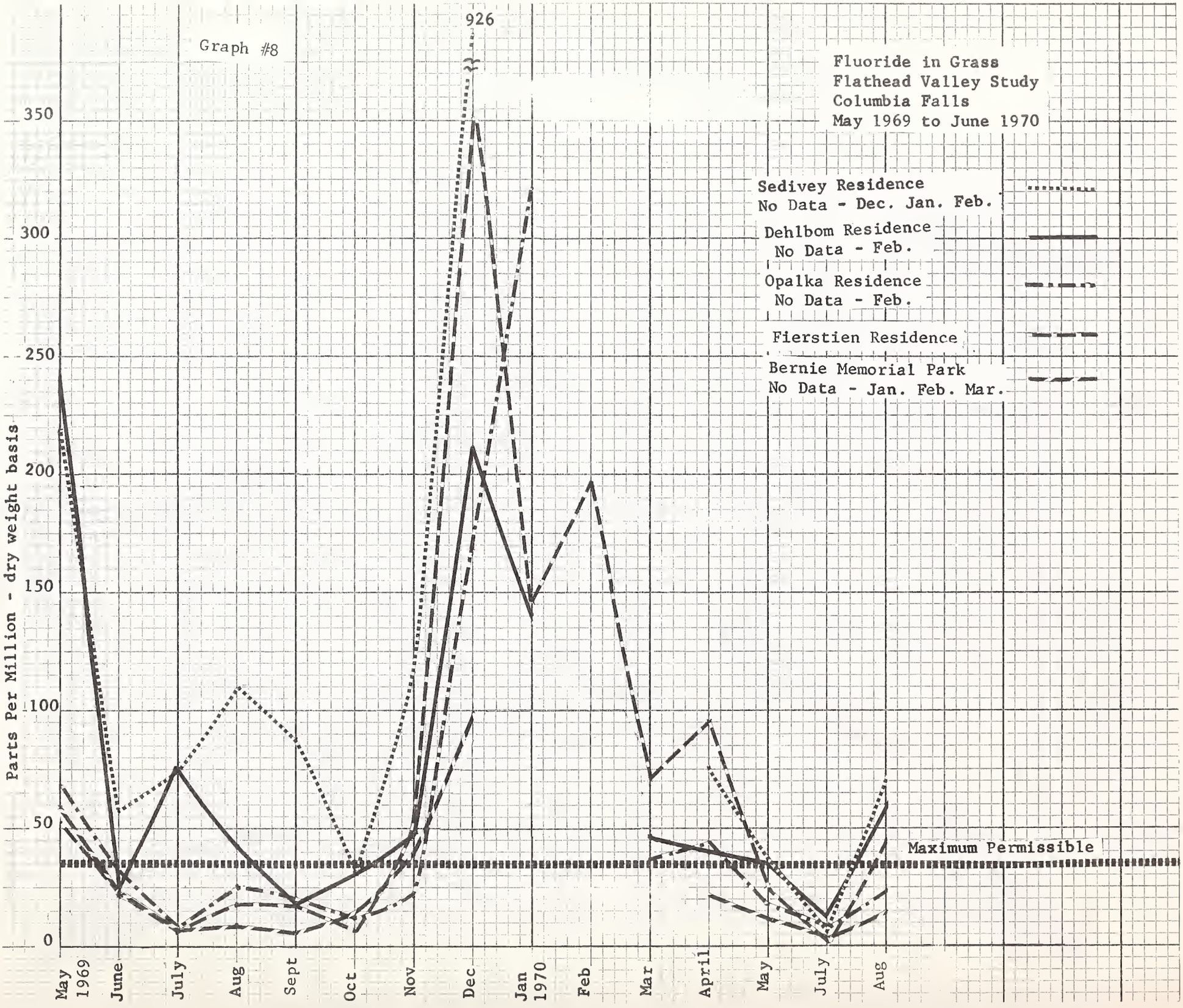
COLUMBIA FALLS AREA

Grass Samples

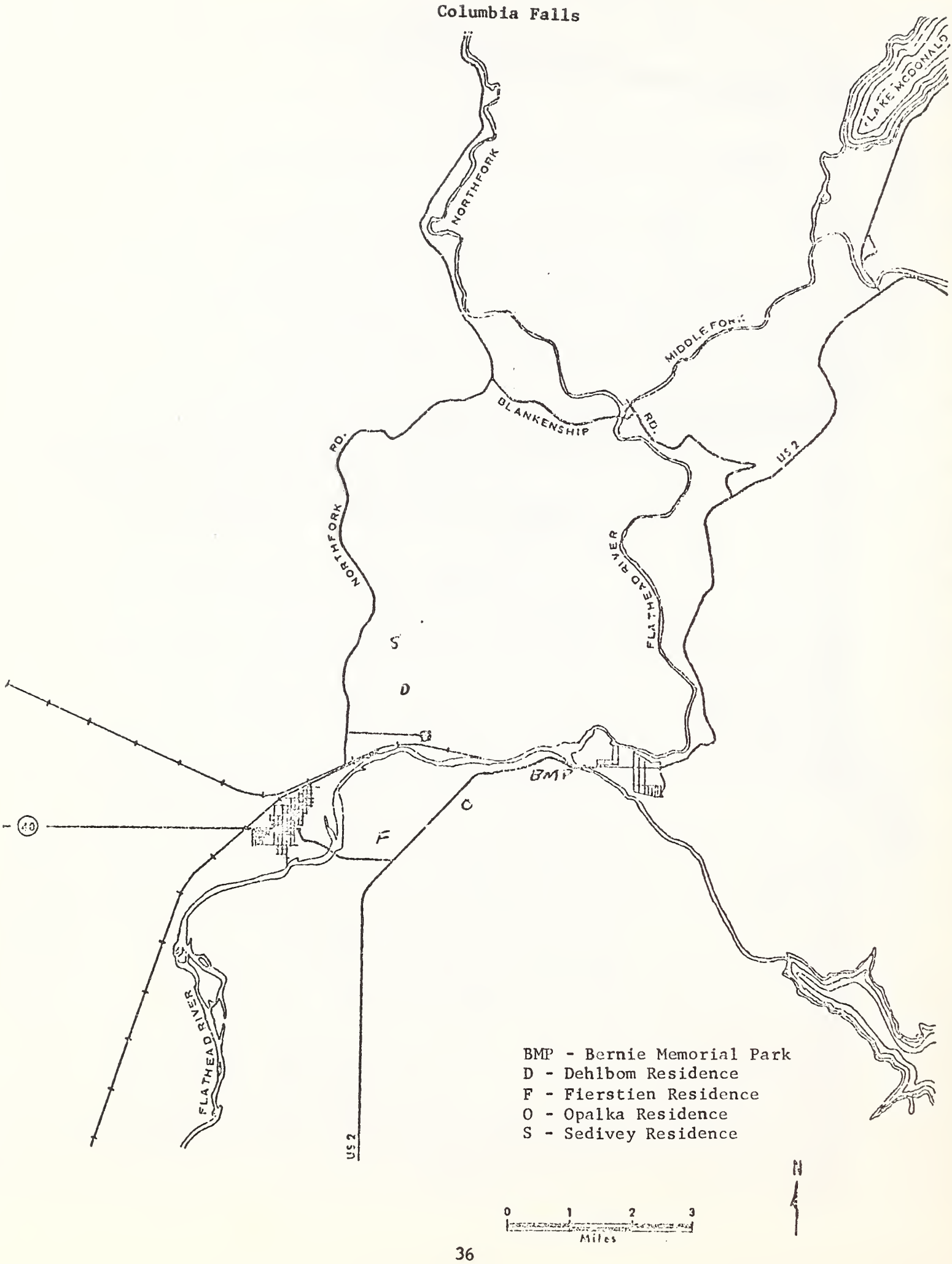
Area of Collection					
Date of Collection	B.M.P	Dehlbom Residence	Fierstien Residence	Opalka Residence	Sedivey Residence
May, 1969	59.2	235	68	53.2	219
June, 1969	24	24	32	22	57
July, 1969	7.3	74	7.6	7.3	74
Aug., 1969	9.9	42.6	25.1	18.6	119
Sept., 1969	5.2	19.6	21.1	17.4	87.6
Oct., 1969	13.6	32.6	12.4	6.1	31.6
Nov., 1969	38.6	49.6	20.1	49.6	115
Dec., 1969	99.6	211	172	351	926
Jan., 1970	N.A.*	140	321	146	N.A.*
Feb., 1970	N.A.*	N.A.*	N.A.*	196	N.A.*
Mar., 1970	N.A.*	46	36	71	N.A.*
April, 1970	22	40	44	95	76
May, 1970	12	36	18	25	36
July, 1970	10	26	6	17	15
Aug., 1970	15	60	40	24	72

*N.A. - Not available due to snow cover

Standard - Maximum 35 parts per million - dry weight basis.


Graph #8
926
Fluoride in Grass
Flathead Valley Study
Columbia Falls
May 1969 to June 1970
Sedivey Residence
No Data - Dec. Jan. Feb.
Dehlbom Residence
No Data - Feb.
Opalka Residence
No Data - Feb.
Fierstien Residence
Bernie Memorial Park
No Data - Jan. Feb. Mar.
Maximum Permissible
Parts Per Million - dry weight basis
350
300
250
200
150
100
50
0
May 1969
June
July
Aug
Sept
Oct
Nov
Dec
Jan 1970
Feb
Mar
April
May
July
Aug

Map IV
Location of Grass Sampling Sites



Evergreens:

Fifty-six samples of evergreen needles were collected and analyzed for fluoride content during the month of June, 1970. All samples were collected within a ten mile radius of the Anaconda Aluminum plant at Columbia Falls.

Sampling was accomplished by taking a grab sample from inner-most to the outer-most needles on three sides of the tree. No attempt was made to date needles for years of exposure. Sampling was limited to five species of trees and was based on availability, in the following order of preference: Lodge-pole Pine, Ponderosa Pine, White Pine, Douglas Fir and Juniper. All samples were taken from a height of approximately five feet above the ground. Six control samples collected on the Rice Ridge Road near Swan Lake showed an average concentration of 7 parts per million fluoride, with a range of 6.4 to 8.4 parts per million.

The resultant fluoride levels are shown on Figure #2 with the center circle representing the Anaconda Aluminum plant. As shown, the maximum value is 3100 ppm at ½ mile northeast of the plant and the minimum value is 9 ppm at the nine mile point south of the plant. In general, the fluoride concentration decreases with distance from the plant. Other studies of fluoride in plant tissue in this area indicate that elevation may be an extremely important factor in controlling the concentration of fluoride in vegetation. Verbal discussion of the preliminary results of a study being done by Dr. C.C. Gordon, University of Montana, show that fluoride hot spots occur at elevations of 3500 to 4500 feet. The data shown on Figure #2 supports this statement.

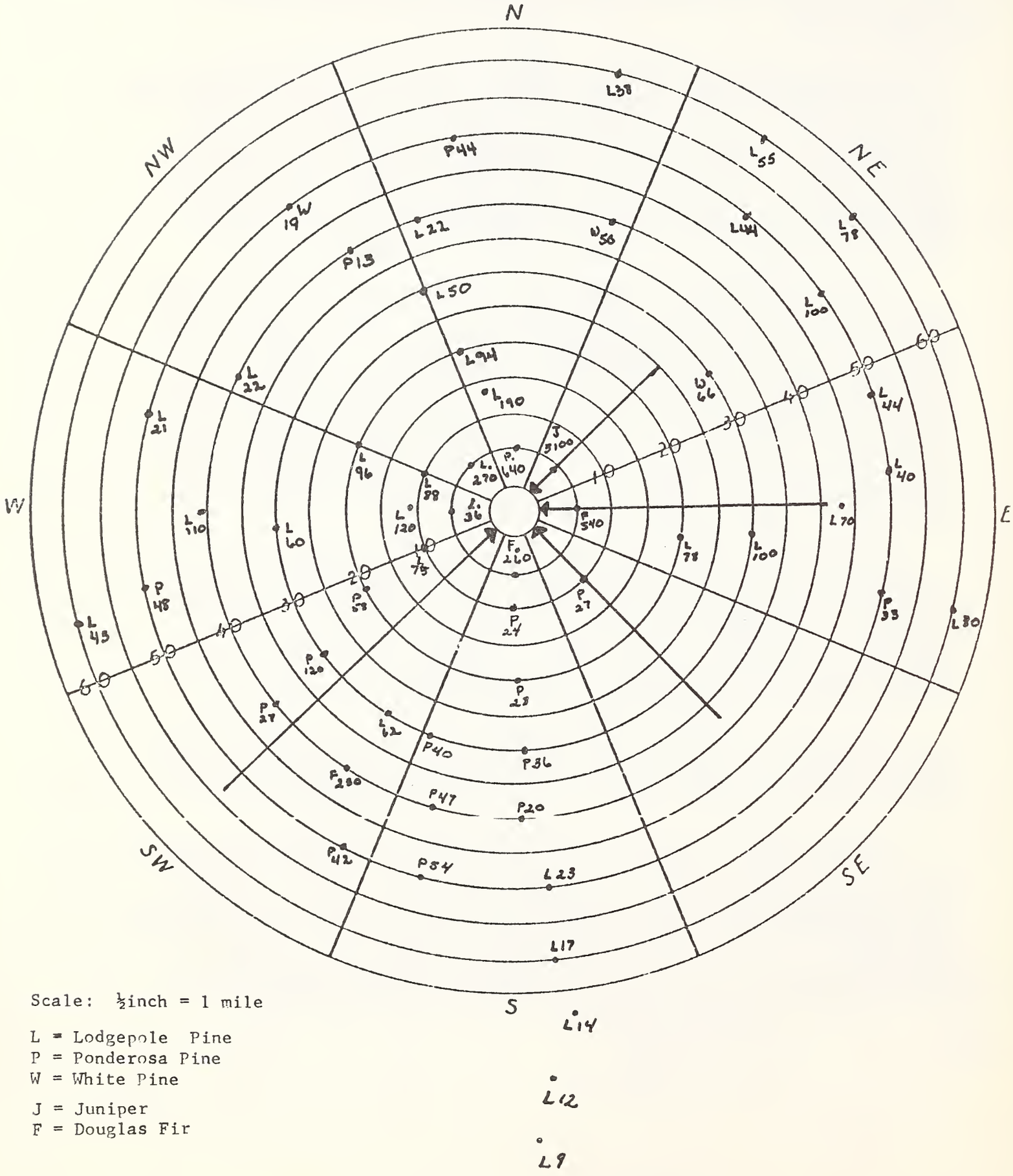
For example, to the south where the elevation is uniform there is a continuous decline in fluoride content with distance from the plant. However, in other directions, high spots in the topography can be seen represented as high fluoride values on Figure #2 with less apparent dependency on distance from the plant. It should also be noted that different species of evergreens and even different members of the same species demonstrate differential rates of absorption of fluoride.

The arrows on Figure #2 show the direction from which the wind blows; with the lengths of the lines representing the percent of the time that the wind blows from that direction. Fluoride values are significantly greater in the direction that the wind blows more frequently.

In many places in the area, the State Standard for gaseous fluoride, calcium formate paper method, is being exceeded only slightly but visible plant damage is evident. At the present time several other studies of fluoride accumulation is the Columbia Falls area are being done. Enclosed as an addendum to this report as the results of a preliminary study performed by Dr. C.C. Gordon of the University of Montana for the State Health Department. Dr. Gordon is now working on a more detailed study as a National Air Pollution Control Administration contractor.

Figure 2

Fluoride in Evergreen Needles - Columbia Falls Area
in parts per million dry weight basis
June 1970



Scale: ½inch = 1 mile

L = Lodgepole Pine
P = Ponderosa Pine
W = White Pine

J = Juniper
F = Douglas Fir

DUSTFALL - COLUMBIA FALLS AREA

Dustfall is a gross measurement of the particulate fallout of an area. A container filled with water is exposed for a period of approximately thirty days after which the collected particulate is weighed. It is expressed as dustfall in tons per square mile per month. The State Ambient Air Quality Standard for dustfall is 15 tons per square mile per month, for a three month average. Dustfall is made up of relatively large particles which settle out of the air close to the source of generation and for this reason shows little dependency on inversion conditions. Common sources of dustfall are wind blown dust, dust raised by the normal activities of a community, dust from unpaved streets and partially burned particles from poor combustion practices.

Five dustfall stations were maintained in the Columbia Falls area, for duration of the study. Map #V shows the location of these sampling sites. Table #11 lists the monthly dustfall collected. Table #12 lists the three months average of these values and Graphs #9 through #13 show the relationships of these values to the State standard by seasons. Reference to Graph #9 shows that during the summer of 1969 all four sampling stations in or near Columbia Falls collected dustfall grossly in excess of the State standard. The sampling site at Dehlbom's residence is rural and, as expected, shows a normal amount of background dustfall generally attributed to wind blown dust, pollen and such things.

A large portion of this heavy dustfall was observed to be partially burned and unburned wood particles emitted by the nearby wood products industries. The dust and dirt portions of these dustfalls were also excessive. A major source of this dust is generated on the many unpaved and dirty paved streets in the surrounding areas. Reference to the High School Station during the winter months, Graph #11, indicates the dust suppressive action of snow on the dusty streets in that area.

Comparison of Graphs #9 and #13 show that there is a downward trend in the generation of dustfall in the area. The decline is primarily due to better combustion practices at the surrounding wood products industries. While unburned wood was still evident in dustfall samples taken during the summer of 1970, the major constituent was dust and dirt from unpaved streets. Application of dust suppressants to unpaved streets and proper cleaning of paved streets plus continued improvement of combustion practices would help tremendously in meeting the Ambient Air Quality Standard for dustfall in this area.

MAP V

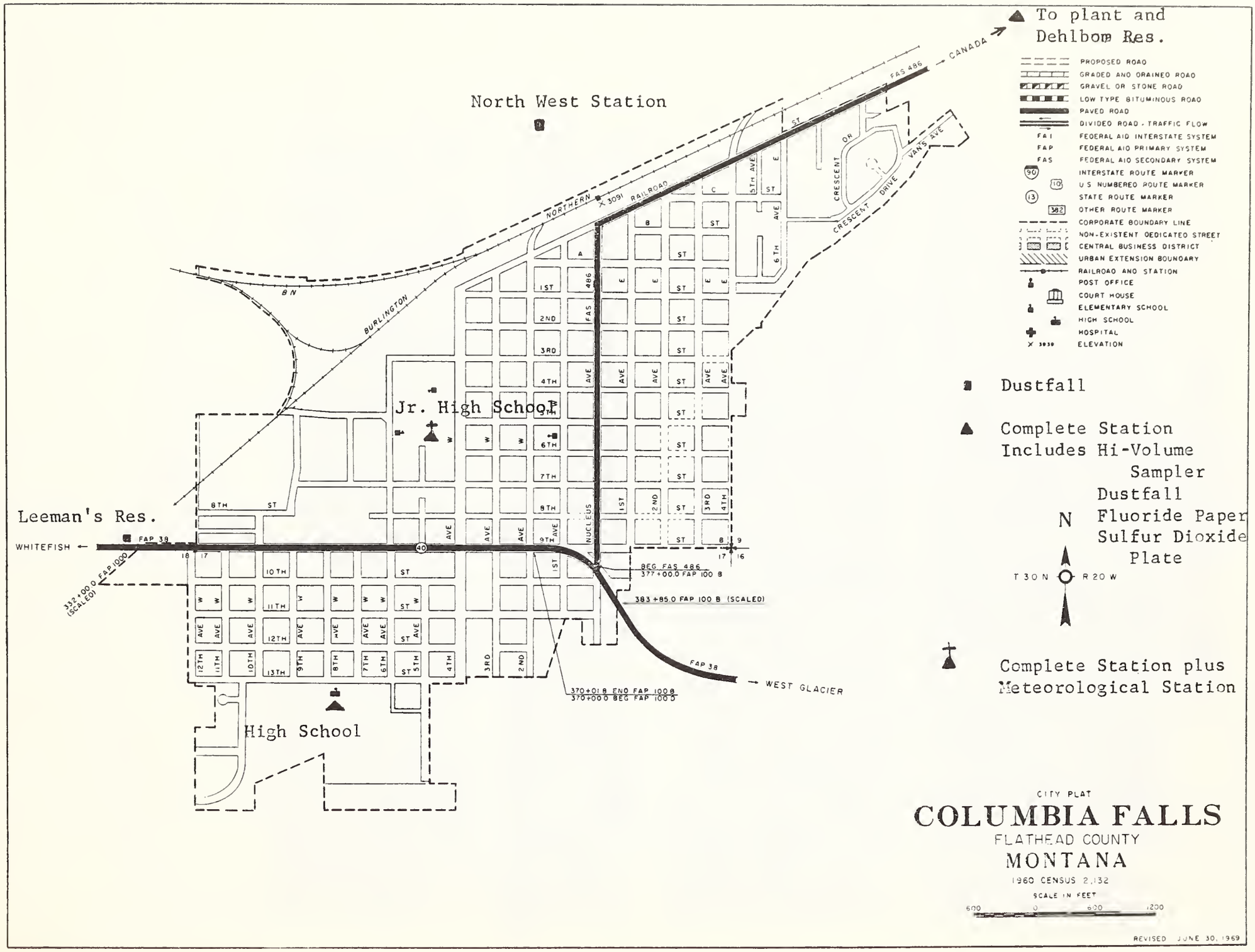

To plant and Dehlbom Res.
North West Station
Jr. High School
High School
Leeman's Res.
WHITEFISH
WEST GLACIER
CANADA
NORTHERN RAILROAD
BURLINGTON
BN
FAS 486
FAP 38
FAP 100
CRESCENT DRIVE
VANS AVE
NUCLEUS
BEG FAS 486
377+00.0 FAP 100 B
383+85.0 FAP 100 B (SCALED)
370+01.8 END FAP 100 B
370+00.0 BEG FAP 100 B
332+00.0 FAP 100 (SCALED)
PROPOSED ROAD
GRADED AND DRAINED ROAD
GRAVEL OR STONE ROAD
LOW TYPE BITUMINOUS ROAD
PAVED ROAD
DIVIDED ROAD - TRAFFIC FLOW
FAI FEDERAL AID INTERSTATE SYSTEM
FAP FEDERAL AID PRIMARY SYSTEM
FAS FEDERAL AID SECONDARY SYSTEM
INTERSTATE ROUTE MARKER
U S NUMBERED ROUTE MARKER
STATE ROUTE MARKER
OTHER ROUTE MARKER
CORPORATE BOUNDARY LINE
NON-EXISTENT DEDICATED STREET
CENTRAL BUSINESS DISTRICT
URBAN EXTENSION BOUNDARY
RAILROAD AND STATION
POST OFFICE
COURT HOUSE
ELEMENTARY SCHOOL
HIGH SCHOOL
HOSPITAL
ELEVATION
Dustfall
Complete Station Includes Hi-Volume Sampler Dustfall Fluoride Paper Sulfur Dioxide Plate
N
T 30 N
R 20 W
Complete Station plus Meteorological Station
CITY PLAT
COLUMBIA FALLS
FLATHEAD COUNTY
MONTANA
1960 CENSUS 2,132
SCALE IN FEET
600 0 600 1200
REVISED JUNE 30, 1969

TABLE #11

DUSTFALL
COLUMBIA FALLS

Tons/mi^2/month

COLUMBIA FALLS					
Date of Collection	Dehlbom Res.	Luce Residence	High School	Jr. High	Leeman Res.
May, 1969	11.2			48.3	79.8
June, 1969	7.8	63.8	29.9	35.0	62.9
July, 1969	1.6	21.5	27.3	24.0	25.0
Aug., 1969	7.0	83.7	30.6	30.5	35.0
Sept., 1969	7.6	60.3	20.1	41.5	44.0
Oct., 1969	3.0	47.1	26.2	9.5	19.4
Nov., 1969	2.8	79.0	12.1	26.0	15.0
Dec., 1969	2.6	84.0	18.7	42.5	11.0
Jan., 1970	.8	40.0	4.5	23.6	6.5
Feb., 1970	32.8	54.6		38.3	37.1
Mar., 1970	0.9	37.1	17.1	27.1	12.0
April, 1970	2.7	58.9	21.2	lost	24.9
May, 1970	3.9	24.2	24.7	27.5	19.4
June, 1970	lost	30.1	lost	28.7	22.4
July, 1970	Discontinued	43.7	Discontinued	22.4	25.5
Aug., 1970		6.3		19.3	20.3
Average	6.5	49.0	21.1	29.6	29.4
Maximum	32.8	84.0	29.9	48.3	79.8
Minimum	0.9	6.3	4.5	9.5	6.5

Standard: 15 tons/mi^2/mo Three Months Average Residential
30 tons/mi^2/mo Three Months Average Heavy Industrial

TABLE #12

DUSTFALL

COLUMBIA FALLS

Tons/Mi^2/Month
Three Month Averages

Date of Collection	COLUMBIA FALLS				
	Dehlbom Res.	Luce Residence	Columbia Falls High School	Columbia Falls Jr. High	Leeman Res.
Mar. - May 69	**11.2	N.A.	N.A.	**48.3	**79.8
June - Aug. 69	5.5	56.3	29.3	29.8	41.0
Sept. - Nov. 69	4.5	62.1	19.5	25.7	26.1
Dec. - Feb. 69-70	12.1	59.5	*11.6	34.8	18.2
Mar. - May 70	2.5	40.1	21.0	*27.3	18.8
June - Aug. 70	Discontinued	26.7	Discontinued	23.5	22.7

N.A. - No data available

*Two Monthly Samples Only
**One Monthly Sample Only

Standard: 15 Tons/Mi^2/Mo. Three Months Average Residential
30 Tons/Mi^2/Mo. Three Months Average Heavy Industrial

DUSTFALL - KALISPELL

Map #VI indicates the location of sampling sites in the Kalispell area. Dustfall in the city of Kalispell is not at this time a serious problem. Primarily, this is due to the large portion of paved streets in the city. Dustfall values for Kalispell are listed monthly on Table #13 and as three month averages on Table #14. The relationships of dustfall to the State Ambient Air Quality Standard by seasons are shown on Graphs #9 through #13.

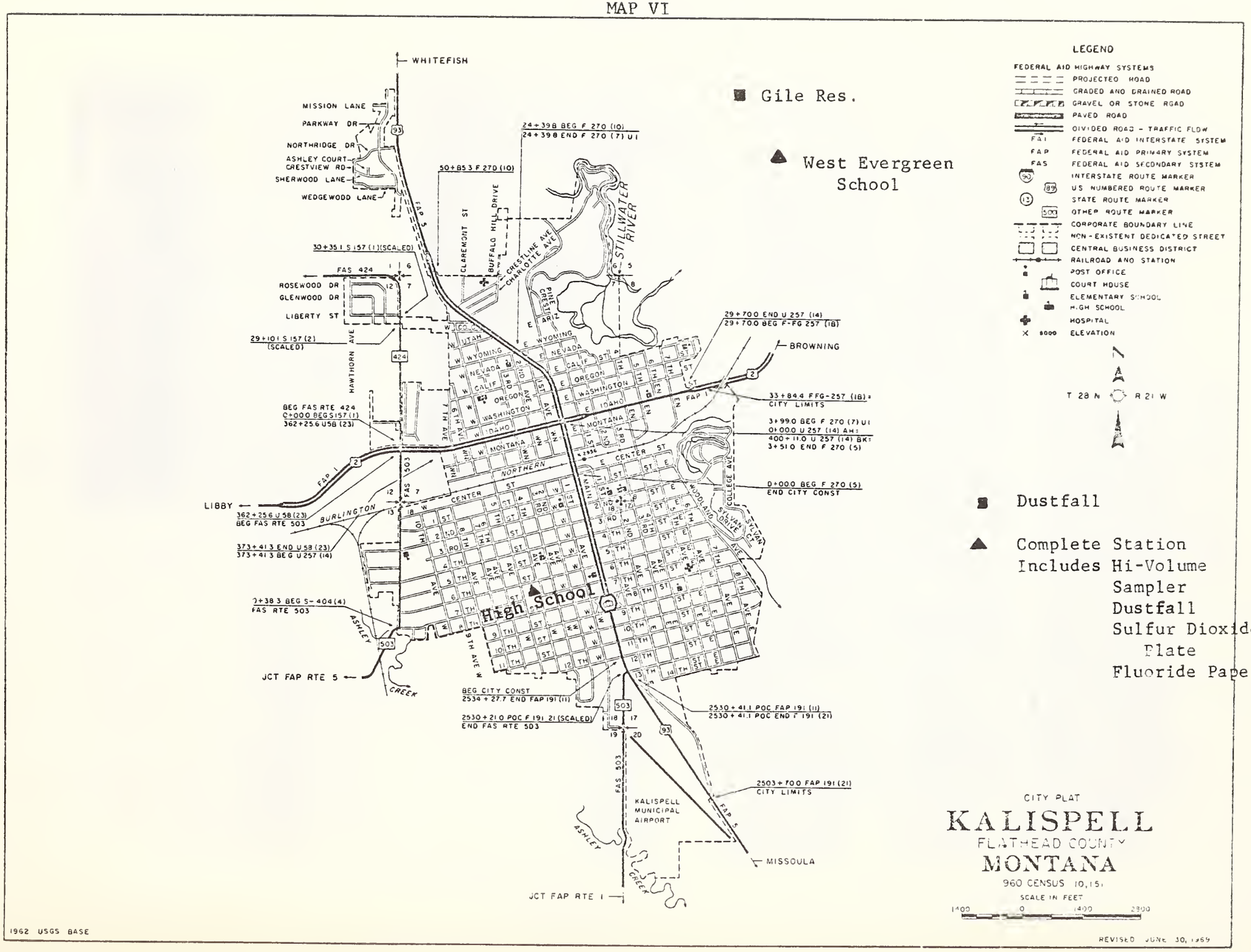
Reference to Graphs #9, #11 and #12 show large values of dustfall for the Kalispell High School station during the summer and winter of 1969, and spring of 1970. This was due to the razing of portions of the old school building. It indicates the necessity for taking dust suppressive action during the demolition of buildings.

Dustfall values at the Gile Residence located in West Evergreen are another matter. This station is located between two lumber products industries, C & C Plywood Company and Montana Saw Service, and the excessive dustfall is indicative of their poor combustion practices. A major portion of the fallout collected was partially burned and unburned wood chips. The general trend of dustfall measurements at this site is downward due to improved combustion practices.

During early 1969 most teepee burners were putting out dense volumes of smoke like this.

Modified teepee burners put out very little smoke when operated correctly.

MAP VI



LEGEND
FEDERAL AID HIGHWAY SYSTEMS
PROJECTED ROAD
GRADED AND DRAINED ROAD
GRAVEL OR STONE ROAD
PAVED ROAD
DIVIDED ROAD - TRAFFIC FLOW
FAI FEDERAL AID INTERSTATE SYSTEM
FAP FEDERAL AID PRIMARY SYSTEM
FAS FEDERAL AID SECONDARY SYSTEM
INTERSTATE ROUTE MARKER
US NUMBERED ROUTE MARKER
STATE ROUTE MARKER
OTHER ROUTE MARKER
CORPORATE BOUNDARY LINE
NON-EXISTENT DEDICATED STREET
CENTRAL BUSINESS DISTRICT
RAILROAD AND STATION
POST OFFICE
COURT HOUSE
ELEMENTARY SCHOOL
HIGH SCHOOL
HOSPITAL
ELEVATION
T 28 N
R 21 W
Gile Res.
West Evergreen School
Dustfall
Complete Station
Includes Hi-Volume
Sampler
Dustfall
Sulfur Dioxide
Plate
Fluoride Paper
WHITEFISH
MISSION LANE
PARKWAY DR
NORTHRIDGE DR
ASHLEY COURT
CRESTVIEW RD
SHERWOOD LANE
WEDGEWOOD LANE
FAP 5
30+35.1 S 157 (1)(SCALED)
FAS 424
ROSEWOOD DR
GLENWOOD DR
LIBERTY ST
29+10.1 S 157 (2) (SCALED)
HAWTHORN AVE
BEG FAS RTE 424
0+00.0 BEG S 157 (1)
362+25.6 U 58 (23)
LIBBY
362+25.6 U 58 (23)
BEG FAS RTE 503
373+41.3 END U 58 (23)
373+41.3 BEG U 257 (14)
0+38.3 BEG S-404 (4)
FAS RTE 503
ASHLEY
CREEK
JCT FAP RTE 5
50+85.3 F 270 (10)
24+39.8 BEG F 270 (10)
24+39.8 END F 270 (7) U1
CLAREMONT ST
BUFFALO HILL DRIVE
CRESTLINE AVE
CHARLOTTE AVE
PINE CREST
STILLWATER RIVER
29+70.0 END U 257 (14)
29+70.0 BEG F-FG 257 (18)
BROWNING
33+84.4 FFG-257 (18) = CITY LIMITS
3+99.0 BEG F 270 (7) U1
0+00.0 U 257 (14) AH=
400+11.0 U 257 (14) BK=
3+51.0 END F 270 (5)
0+00.0 BEG F 270 (5)
END CITY CONST
COLLEGE AVE
SYLVAN DRIVE
WOODLAND AVE
NORTHERN
BURLINGTON
CENTER ST
MAIN
High School
BEG CITY CONST
2534+27.7 END FAP 191 (11)
2530+21.0 POC F 191 21 (SCALED)
END FAS RTE 503
2530+41.1 POC FAP 191 (11)
2530+41.1 POC END F 191 (21)
2503+70.0 FAP 191 (21)
CITY LIMITS
KALISPELL MUNICIPAL AIRPORT
MISSOULA
JCT FAP RTE 1
CITY PLAT
KALISPELL
FLATHEAD COUNTY
MONTANA
960 CENSUS 10,151
SCALE IN FEET
1400 0 1400 2800
1962 USGS BASE
REVISED JUNE 30, 1969

DUSTFALL - POLSON

Sampling station locations in the Polson area are shown on Map #VII. Monthly dustfall values are listed on Table #13 with three month values listed on Table #14. The relationship of one station, the Trussler Residence, to the State Ambient Air Quality Standard are shown on Graphs #9 through #13.

Dustfall values within the city are generally low and do not indicate a serious dustfall problem at this time. This is primarily due to the large portion of paved versus unpaved streets within the city limits. Dustfall values at the Trussler Residence are extremely high and due completely to the poor combustion practices of the upwind wind Dupuis Brothers wood products industry. The Trussler Residence is in a rural location and should show the normal rural background for the area of about 5 tons of dustfall per square mile per month. The 17 to 40 tons of dustfall in excess of the normal rural background is entirely attributable to the upwind source. Comparison of Graph #9 and Graph #13 will show, however, that combustion practices have improved slightly over the past year.

DUSTFALL - LIBBY

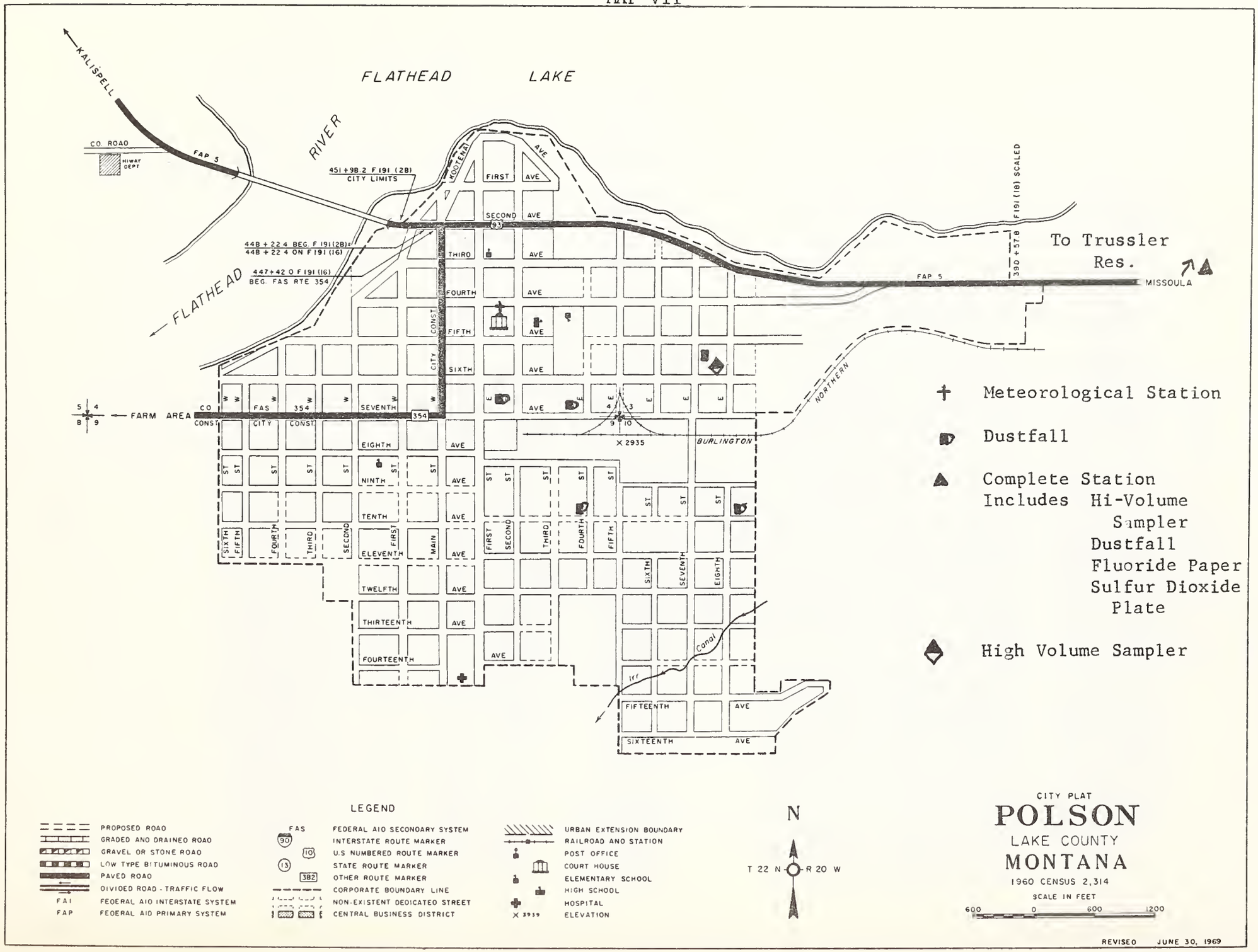
The location of sampling stations in the Libby area are shown on Map #VIII. Monthly dustfall values are listed on Table #13 and three month averages are listed on Table #14. Graphs #9 through #13 show the three month average dustfall values in respect to the State Ambient Air Quality Standard.

The Asa Wood School sampling site indicates excessive dustfall. The Ambient Air Quality Standard is exceeded at this site which is attributed solely to the dirtiness of streets in the town. Almost no wood particles were apparent in any of the samples collected. An efficient street cleaning program on paved streets and employment of dust suppressant tactics to unpaved streets would hlep to alleviate this problem.

It should be noted that street construction in the general area contributed to the excessive dustfall collection in the summer of 1970.

The Sprague Residence station is located in a rural residential area downwind from St. Regis Lumber Company. It is, however, located too far away to be affected significantly by particle fallout from the plant. At any rate, the discontinuance of burning wood waste in teepee burners by this company should resolve any fallout problem which may have existed as a result of this plant.

MAP VII


FLATHEAD LAKE
RIVER
FLATHEAD
KALISPELL
CO. ROAD
HIWAY DEPT
FAP 5
451+98.2 F191 (28) CITY LIMITS
448+22.4 BEG. F191(28)= 448+22.4 ON F191(16)
447+42.0 F191(16) BEG. FAS RTE 354
KOOTENAI
FIRST AVE
SECOND AVE
THIRD AVE
FOURTH AVE
FIFTH AVE
SIXTH AVE
SEVENTH AVE
EIGHTH AVE
NINTH AVE
TENTH AVE
ELEVENTH AVE
TWELFTH AVE
THIRTEENTH AVE
FOURTEENTH AVE
FIFTEENTH AVE
SIXTEENTH AVE
CITY CONST
FAS 354
CO CONST
FARM AREA
BURLINGTON
NORTHERN
Irr Canal
X 2935
F191 (18) SCALED
390+57.8
To Trussler Res.
MISSOULA
Meteorological Station
Dustfall
Complete Station Includes Hi-Volume Sampler Dustfall Fluoride Paper Sulfur Dioxide Plate
High Volume Sampler
LEGEND
PROPOSED ROAD
GRADED AND DRAINED ROAD
GRAVEL OR STONE ROAD
LOW TYPE BITUMINOUS ROAD
PAVED ROAD
DIVIDED ROAD - TRAFFIC FLOW
FAI FEDERAL AID INTERSTATE SYSTEM
FAP FEDERAL AID PRIMARY SYSTEM
FAS FEDERAL AID SECONDARY SYSTEM
INTERSTATE ROUTE MARKER
U.S NUMBERED ROUTE MARKER
STATE ROUTE MARKER
OTHER ROUTE MARKER
CORPORATE BOUNDARY LINE
NON-EXISTENT DEDICATED STREET
CENTRAL BUSINESS DISTRICT
URBAN EXTENSION BOUNDARY
RAILROAD AND STATION
POST OFFICE
COURT HOUSE
ELEMENTARY SCHOOL
HIGH SCHOOL
HOSPITAL
ELEVATION
N
T 22 N
R 20 W
CITY PLAT
POLSON
LAKE COUNTY
MONTANA
1960 CENSUS 2,314
SCALE IN FEET
600 0 600 1200
REVISED JUNE 30, 1969

MAP VIII

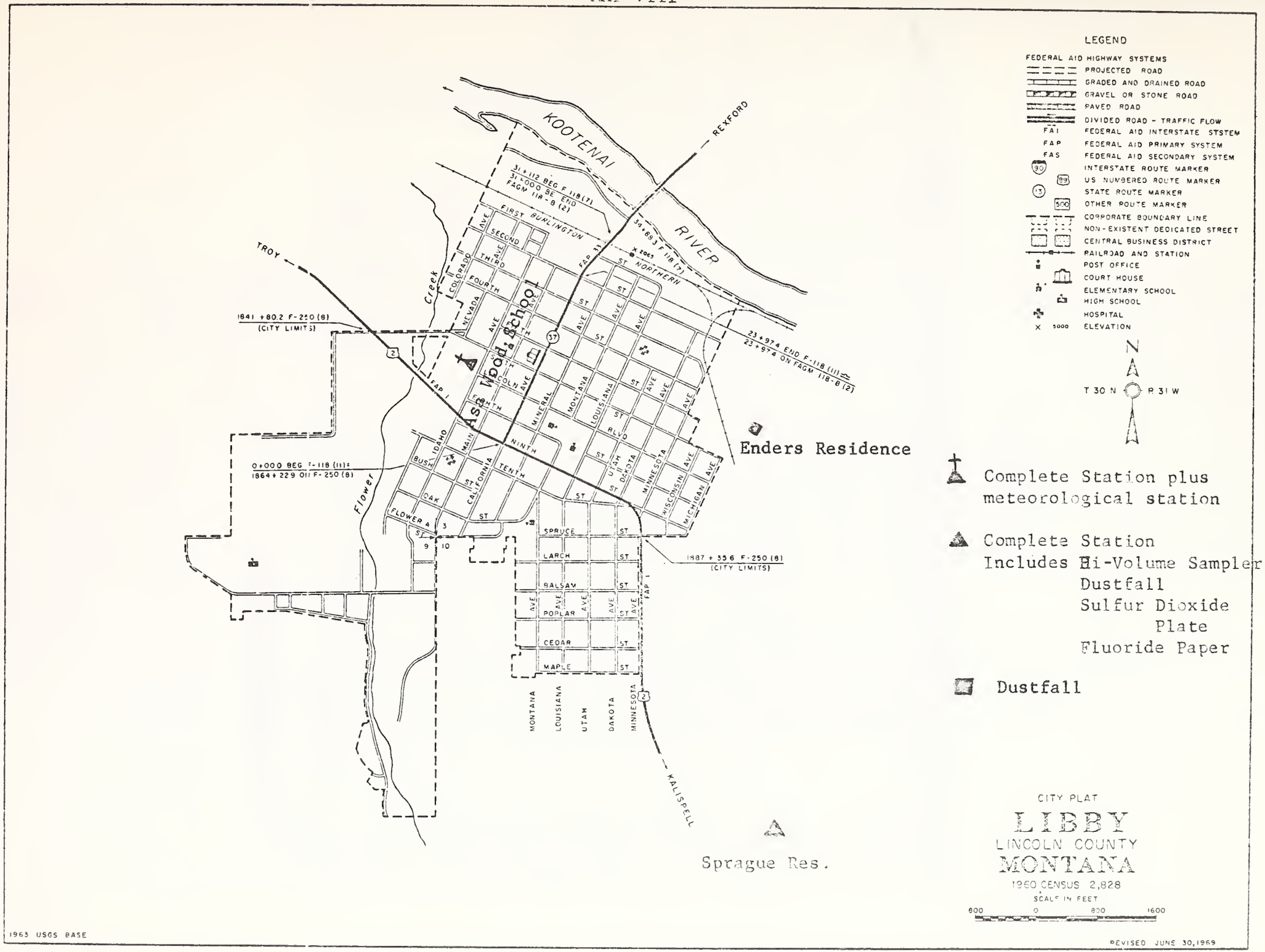

LEGEND
FEDERAL AID HIGHWAY SYSTEMS
PROJECTED ROAD
GRADED AND DRAINED ROAD
GRAVEL OR STONE ROAD
PAVED ROAD
DIVIDED ROAD - TRAFFIC FLOW
FAI FEDERAL AID INTERSTATE STSTEM
FAP FEDERAL AID PRIMARY SYSTEM
FAS FEDERAL AID SECONDARY SYSTEM
INTERSTATE ROUTE MARKER
US NUMBERED ROUTE MARKER
STATE ROUTE MARKER
OTHER ROUTE MARKER
CORPORATE BOUNDARY LINE
NON-EXISTENT DEDICATED STREET
CENTRAL BUSINESS DISTRICT
RAILROAD AND STATION
POST OFFICE
COURT HOUSE
ELEMENTARY SCHOOL
HIGH SCHOOL
HOSPITAL
5000 ELEVATION
N
T 30 N
R 31 W
KOOTENAI
RIVER
REXFORD
TROY
KALISPELL
Creek
Flower
As Wood School
Enders Residence
Sprague Res.
31+112 BEG F 118(7)
31+000 BE END FAGM 118-B (2)
34+883 F 118 (7)
23+974 END F-118 (11)
23+974 ON FAGM 118-B (2)
1841 +80.2 F-250 (8)
(CITY LIMITS)
0+000 BEG F-118 (11)
1864+229 ON F-250 (8)
1887 + 35.6 F-250 (8)
(CITY LIMITS)
FIRST BURLINGTON
NORTHERN
SECOND
THIRD
FOURTH
COLORADO
NEVADA
FIFTH
SIXTH
COLN
EIGHTH
NINTH
TENTH
MAIN
IDAHO
BUSH
OAK
CALIFORNIA
FLOWER A
MINERAL
MONTANA
LOUISIANA
UTAH
DAKOTA
MINNESOTA
WISCONSIN
MICHIGAN
BLVD
SPRUCE
LARCH
BALSAM
POPLAR
CEDAR
MAPLE
FAP 33
FAP 1
Complete Station plus meteorological station
Complete Station
Includes Hi-Volume Sampler
Dustfall
Sulfur Dioxide Plate
Fluoride Paper
Dustfall
CITY PLAT
LIBBY
LINCOLN COUNTY
MONTANA
1960 CENSUS 2,828
SCALE IN FEET
800 0 800 1600
1963 USGS BASE
REVISED JUNE 30,1969

Table #13

Dustfall

Kalispell - Libby - Polson

Tons/Mi^2/Mo.

Date of Collection	Kalispell			Libby					Polson			
	Gile Residence	High School	West Evergreen School	Asa Wood School	Enders Res.	Spragues Res.	Connell Res.	Corrigan Res.	Mertz Res.	Minette Res.	Trussler Res.	Wells Res.
Oct. 1968							6.1	5.4	10.1	8.0		3.2
Nov. 1968							2.5	2.5	5.1	Lost		Lost
Dec. 1968							4.6	5.4	8.8	7.7		1.8
Jan. 1969							0.8	0.1	2.4	0.1		2.5
Feb. 1969							1.4	1.3	3.1	0.7		0.4
Mar. 1969							6.3	8.0	22.8	7.0		4.1
April 1969			Start of Flathead Valley Study									
May 1969	33.2	18.3	Lost	29.1		9.7	*13.7	*16.0	*22.9	*11.9	35.1	*5.8
June 1969	36.4	36.0	14.4	25.3		11.9	Lost	Lost	Lost	22.3	48.9	29.8
July 1969	33.4	10.0	7.5	14.3		9.1	10.1	13.9	9.5	9.7	26.8	5.5
Aug. 1969	73.9	30.2	14.9	12.6		11.7	15.2	23.2	18.2	9.0	52.2	16.5
Sept. 1969	61.0	14.7	11.9	16.7		Lost	10.7	16.5	10.4	12.1	45.3	Lost
Oct. 1969	20.0	6.5	6.4	16.0		6.0	3.3	4.7	4.0	3.4	36.5	1.8
Nov. 1969	26.0	5.2	4.2	21.1		4.8	3.4	4.4	5.5	4.2	53.2	Lost
Dec. 1969	18.5	4.9	6.1	22.5		4.4	1.9	Lost	4.0	2.5	45.6	Lost
Jan. 1970	8.2	2.1	2.9	10.6	30.6	2.7	Discontinued	Discontinued	2.3	Discontinued	45.8	Discontinued
Feb. 1970	14.7	48.9	Lost	6.0	23.0	Lost	"	"	5.8	"	26.0	"
Mar. 1970	22.9	8.9	3.0	19.7	19.1	4.8	"	"	8.6	"	29.5	"
April 1970	29.7	20.2	10.4	28.7	23.8	8.8	"	"	14.0	"	25.5	"
May 1970	9.0	15.2	13.7	27.7	39.1	6.6	"	"	23.2	"	27.1	"
June 1970	15.7	7.6	8.2	39.0	29.6	7.7	"	"	Lost	"	Lost	"
July 1970	33.0	Discontinued	7.2	28.2	20.1	Discontinued	"	"	13.9	"	22.3	"
Aug. 1970	20.5	"	11.3	Lost	28.1	"	"	"	8.3	"	18.2	"
Average	26.8	14.3	8.7	21.2	26.6	7.4	6.2	8.5	10.1	7.6	35.9	7.1
Maximum	73.9	48.9	14.9	39.0	39.1	11.7	15.2	23.2	23.2	22.3	53.2	29.8
Minimum	8.2	2.1	2.9	6.0	19.1	2.7	0.8	0.1	2.3	0.1	22.3	0.4

Klinger Mill Area - Mar. 26.27 T/Mi^2/Mo.

*Two Month Exposure

Standard: 15 Tons/Mi^2/Mo. Three Months Average Residential
30 Tons/Mi^2/Mo. Three Months Average Heavy Industrial

TABLE #14

DUSTFALL

KALISPELL - LIBBY - POLSON

Tons/Mi^2/Mo
Three Month Averages

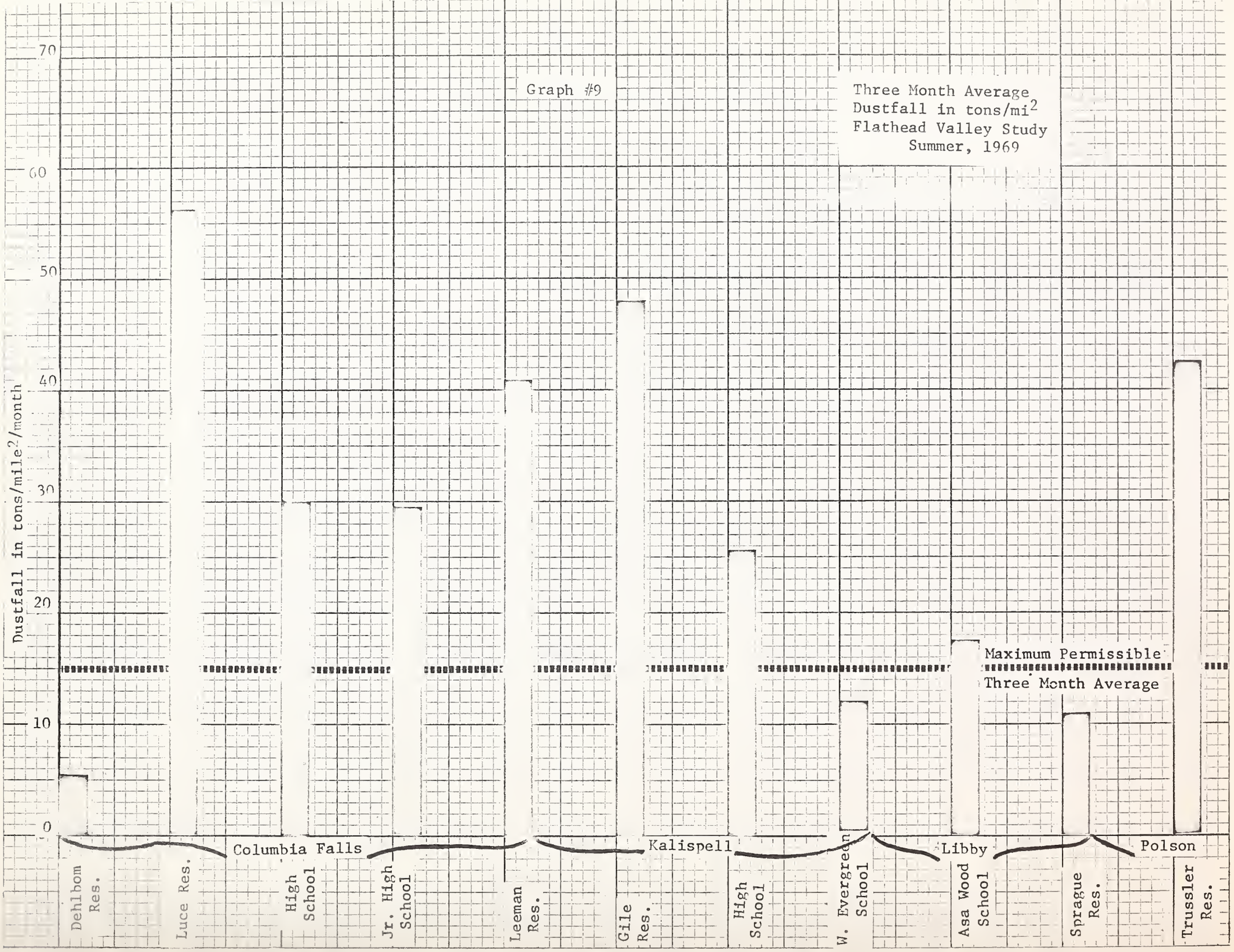
Date of Collection	KALISPELL			LIBBY				POLSON				
	Giles Res.	High School	West Evergreen School	Asa Wood School	Enders Res.	Sprague Res.	Connell Res.	Corrigan Res.	Mertz Res.	Minnette Res.	Trussler Res.	Wells Res.
Oct - Nov 68							*4.3	*4.0	*7.6	**8.0		**3.2
Dec - Feb 68-69		START OF FLATHEAD VALLEY STUDY					2.3	2.3	4.7	2.8		1.6
Mar - May 69	33.2	18.3	Lost	29.1		9.7	10.0	12.0	22.9	9.5	35.1	5.0
June - Aug 69	47.9	25.4	12.27	17.4		10.9	12.7	18.6	13.9	13.7	42.6	1.0
Sept - Nov 69	34.7	8.8	7.5	17.9		5.4	5.8	8.5	6.6	6.6	45.0	17.3
Dec - Feb 69-70	13.8	18.6	*4.5	13.0	26.8	3.6	**1.8	--	4.0	**2.5	39.1	**1.8
Mar - May 70	20.5	14.8	9.1	25.4	27.3	27.3			15.2		27.4	
June - Aug 70	23.1	**7.6	8.9	*33.6	25.9	**7.7			*16.1		*20.3	

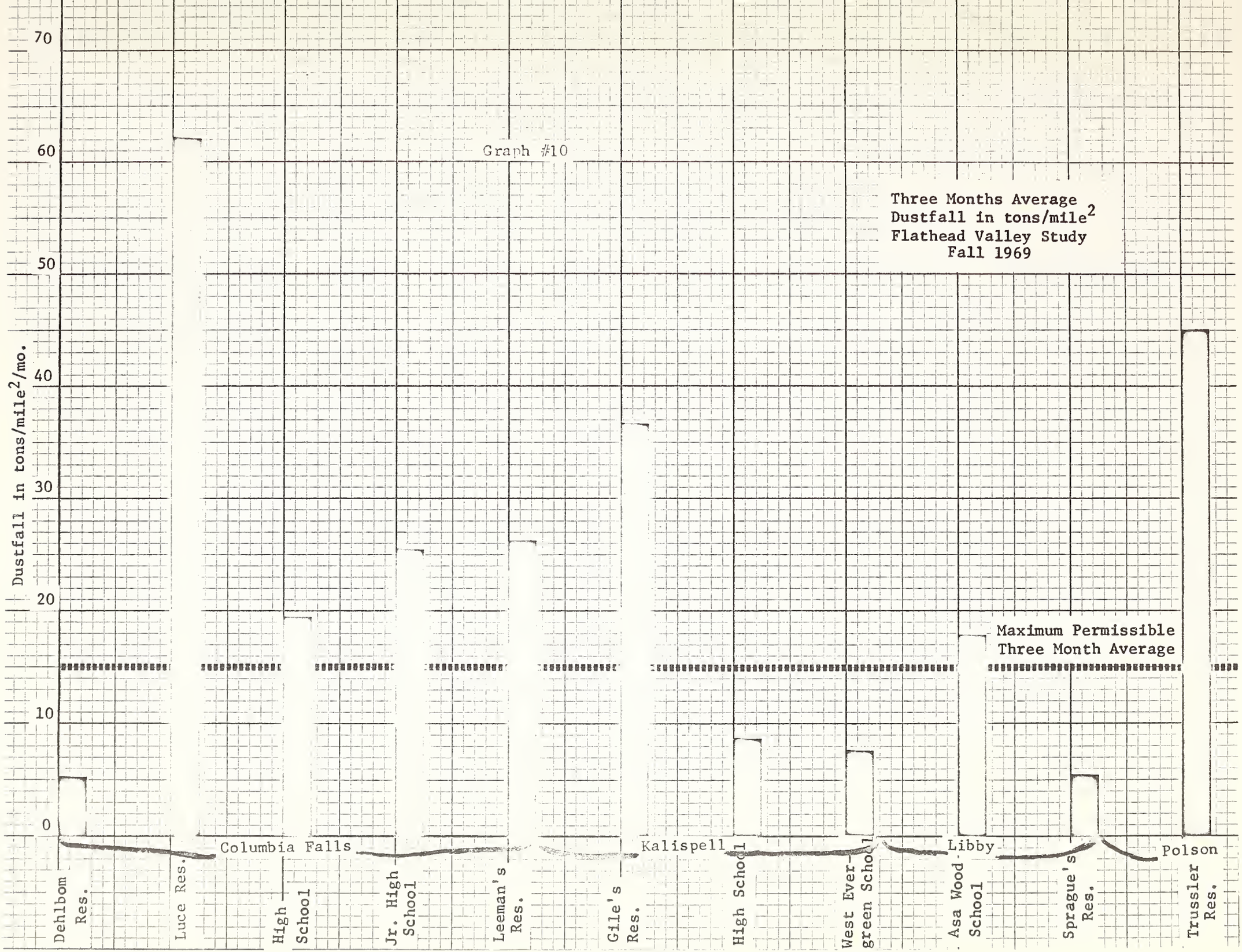
*Two Monthly Samples Only

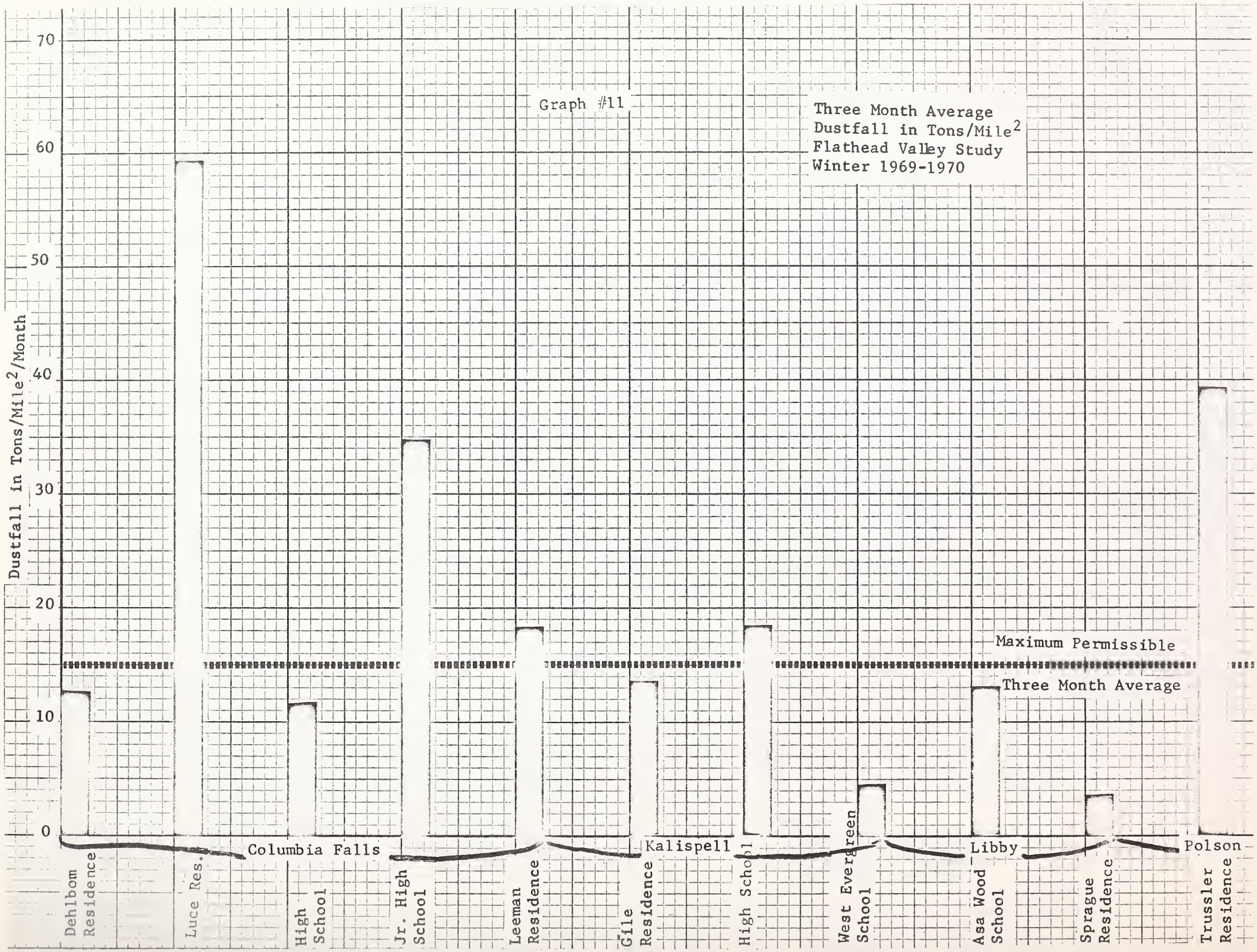
**One Monthly Sample Only

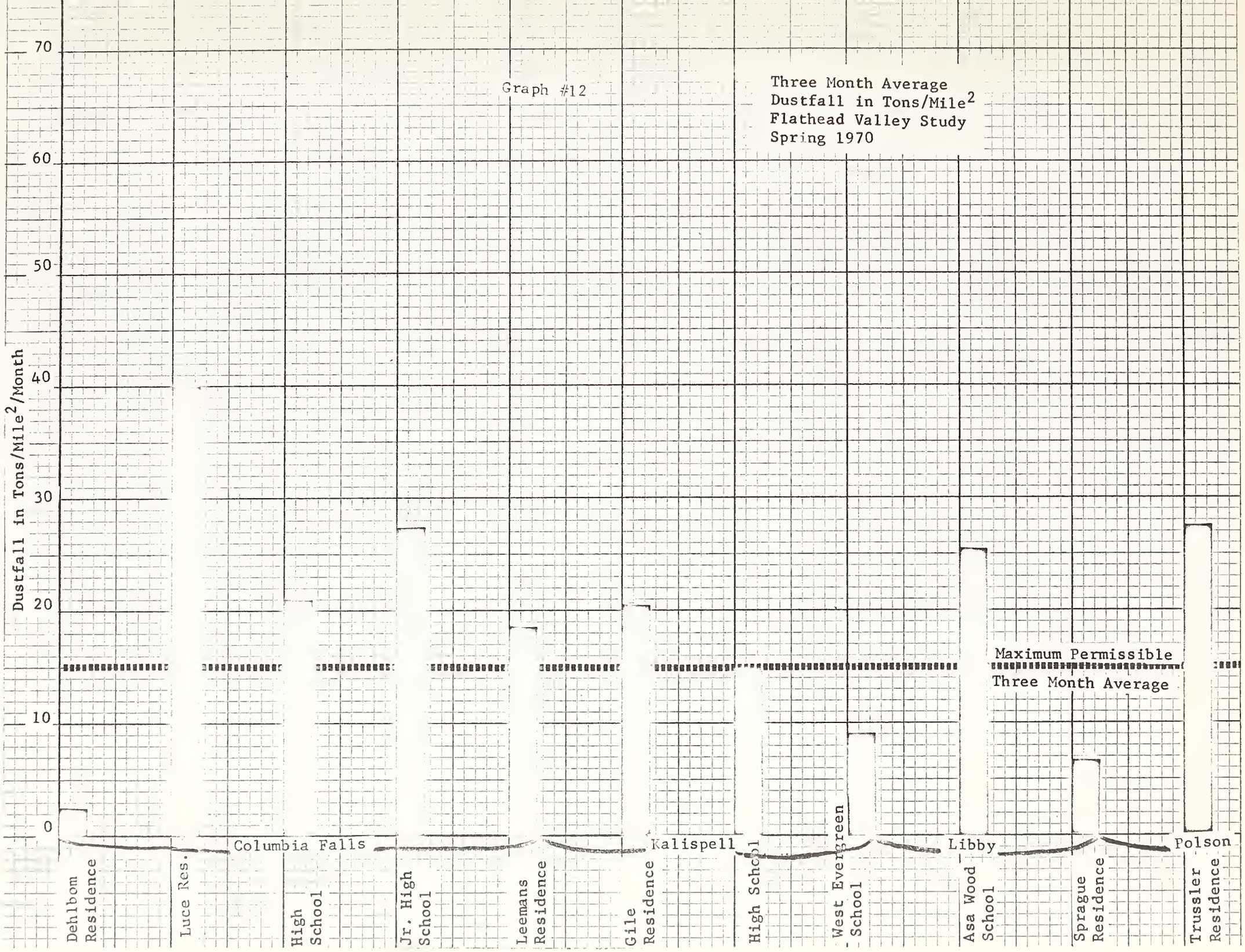
Standard: 15 tons per square mile per month, 3 month average in residential areas

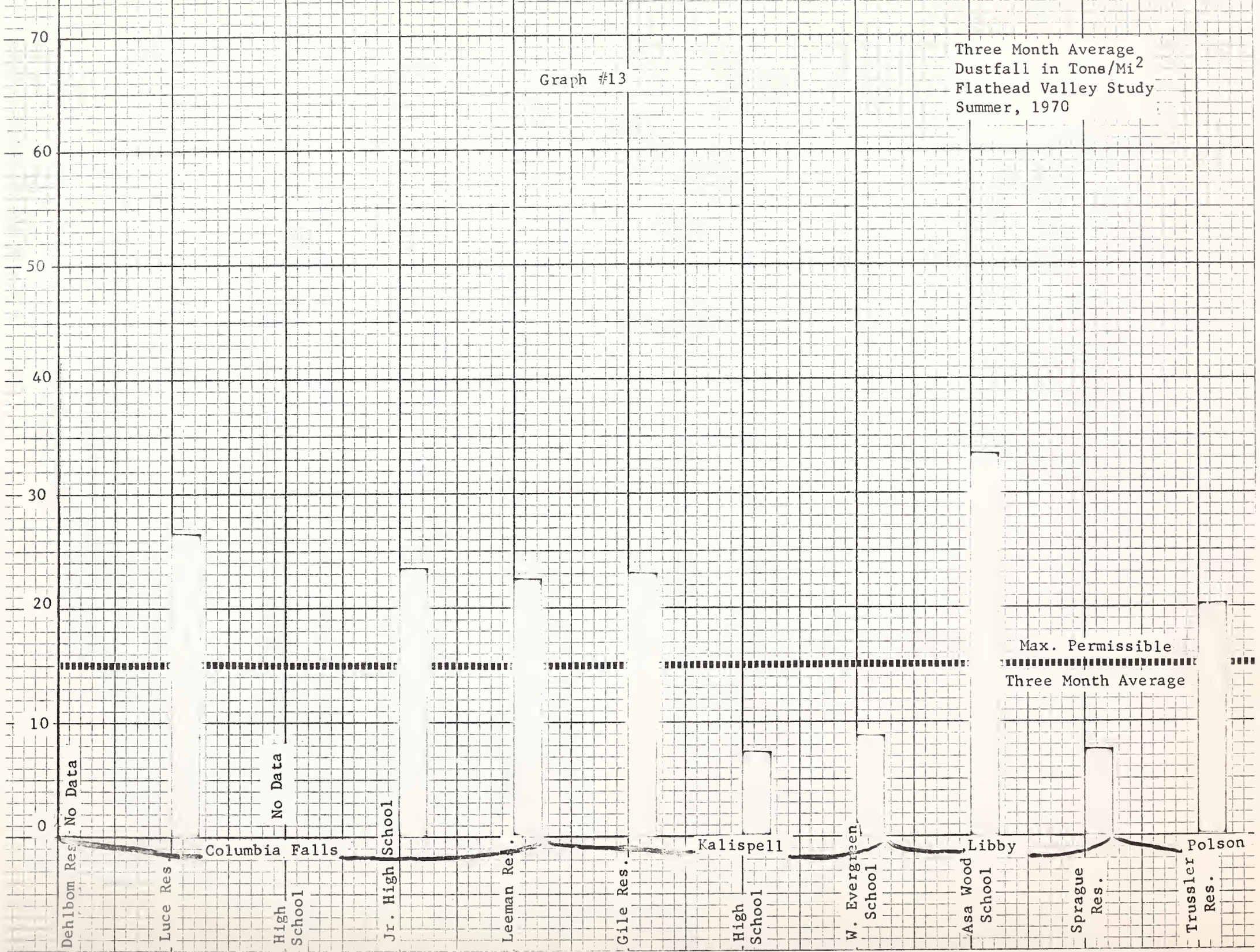
30 tons per square mile per month, 3 month average in heavy industrial areas


Graph #9
Three Month Average
Dustfall in tons/mi^2
Flathead Valley Study
Summer, 1969
Dustfall in tons/mile^2/month
70
60
50
40
30
20
10
0
Maximum Permissible
Three Month Average
Columbia Falls
Kalispell
Libby
Polson
Dehlbom Res.
Luce Res.
High School
Jr. High School
Leeman Res.
Gile Res.
High School
W. Evergreen School
Asa Wood School
Sprague Res.
Trussler Res.


Graph #10
Three Months Average
Dustfall in tons/mile2
Flathead Valley Study
Fall 1969
Dustfall in tons/mile2/mo.
70
60
50
40
30
20
10
0
Maximum Permissible
Three Month Average
Columbia Falls
Kalispell
Libby
Polson
Dehlbom Res.
Luce Res.
High School
Jr. High School
Leeman's Res.
Gile's Res.
High School
West Evergreen School
Asa Wood School
Sprague's Res.
Trussler Res.


Graph #11
Three Month Average
Dustfall in Tons/Mile^2
Flathead Valley Study
Winter 1969-1970
Dustfall in Tons/Mile^2/Month
70
60
50
40
30
20
10
0
Maximum Permissible
Three Month Average
Columbia Falls
Kalispell
Libby
Polson
Dehlbom Residence
Luce Res.
High School
Jr. High School
Leeman Residence
Gile Residence
High School
West Evergreen School
Asa Wood School
Sprague Residence
Trussler Residence


Graph #12
Three Month Average
Dustfall in Tons/Mile2
Flathead Valley Study
Spring 1970
Dustfall in Tons/Mile2/Month
70
60
50
40
30
20
10
0
Maximum Permissible
Three Month Average
Columbia Falls
Kalispell
Libby
Polson
Dehlbom Residence
Luce Res.
High School
Jr. High School
Leemans Residence
Gile Residence
High School
West Evergreen School
Asa Wood School
Sprague Residence
Trussler Residence


Graph #13
Three Month Average
Dustfall in Tons/Mi^2
Flathead Valley Study
Summer, 1970
70
60
50
40
30
20
10
0
Max. Permissible
Three Month Average
No Data
No Data
Columbia Falls
Kalispell
Libby
Polson
Dehlbom Res.
Luce Res.
High School
Jr. High School
Leeman Res.
Gile Res.
High School
W. Evergreen School
Asa Wood School
Sprague Res.
Trussler Res.

REACTIVE SULFUR - FLATHEAD VALLEY

Reactive sulfur or sulfation rate is a gross measure of the reactive sulfur compounds, mostly sulfur dioxide, in the air. Sulfur oxides are generally products of the combustion of fossil fuels, oil and gasoline. Large amounts of sulfur oxides are often emitted during the primary smelting of non-ferrous metals in Montana.

Measurement of the sulfation rate is accomplished by exposing a lead oxide coated cylinder or plate for a period of time and measuring the reaction product. It is expressed as milligrams of sulfur trioxide per 100 square centimeters per day. The State Ambient Air Quality Standard is 0.25 mg SO_3/100 cm^2/day maximum annual average and 0.50 mg SO_3/100 cm^2/day maximum for any one month period.

Measurement of reactive sulfur at six complete air sampling locations in the Flathead Valley was done for four months during 1969. Sampling for reactive sulfur was discontinued after the four months because of the small amount present. Table #15 lists the sulfation rates for the sampling period.

Although the level of reactive sulfur in the Flathead Valley is low, Graph #2 shows a large increase during the six year period from 1963 to 1969. Just what is causing this increase is not clear. Possibly it is due to increased space heating and/or increased use of automobiles.

REACTIVE SULFUR - LIBBY

The reactive sulfur levels in Libby are low and are not considered to be significant at this time. Values found are listed on Table #12.

The levels at Asa Wood school are higher than those found in the Flathead Valley. This is probably due to the more prevalent use of oil for space heating in the Libby Area.

TABLE #15

Reactive Sulfur - Flathead Valley Study

Milligrams $SO_3/100cm^2/day$
(Lead Peroxide Candle)

Date of Collection	COLUMBIA FALLS			LIBBY		KALISPELL		POLSON
	High School	Jr. High School	Dehlbom	Asa Wood	Sprague	High School	West Evergreen	Trussler
May, 1969	No Data	0.05	0.05	0.10	0.05	0.06	0.06	0.04
June, 1969	0.03	0.04	0.02	0.03	0.04	0.05	0.04	0.02
July, 1969	0.02	0.03	0.03	0.05	0.02	0.02	0.02	N.D.
Aug., 1969	0.06	0.06	0.05	0.04	0.03	0.05	0.03	0.04
Average	0.037	0.045	0.038	0.055	0.035	0.045	0.038	0.025
Maximum	0.06	0.06	0.05	0.10	0.05	0.06	0.06	0.04
Minimum	0.02	0.03	0.02	0.03	0.02	0.02	0.02	N.D.

Standard: $0.25mgSO_3/100cm^2/day$ Maximum Annual Average

$0.50mgSO_3/100cm^2/day$ Maximum for any one month period

SUSPENDED PARTICULATE MATTER

Suspended particulate matter consists of tiny particles which usually stay suspended in the air for relatively long periods of time. They are small enough to be drawn into the lungs where some of the particles will be retained. Collection of suspended particulate sample is accomplished by drawing a large volume of air through a glass fiber filter and then determining the weight of the collected particles. The data is expressed in micrograms of suspended particulate per cubic meter (ug/m^3) annual geometric mean not to exceed 200 ug/m^3 for more than one percent of the days of the year.

Portions of the filter are also used to analyze for specific particulate contaminants. During this study, analysis was made for the benzene soluble, sulfate, arsenic and lead fractions of the suspended particulate.

Table #16 lists the results of all of these analyses for the entire study area. Reference to this table shows that the suspended particulate matter collected was in excess of the State Ambient Air Quality Standard at every sampling site but the Dehlbom Residence, located rurally, near Columbia Falls. At all stations the most significant contributing factor to the suspended particulate loading of the air was dust from unpaved and dirty paved streets.

Columbia Falls Area

The locations of the three suspended particulate sampling sites in the Columbia Falls area are shown on Map #V. Reference to Table #16 shows the highest average particulate collection was made at the Columbia Falls Junior High School. This is to be expected because it is the most centrally located sampling station with regard to community activity. The high school station on the outskirts of town shows a somewhat lower average but the measured particulate is still well over the State Standard. Reference to the extremely low average suspended particulate collected at both of these stations, during the winter months (Table #16) when the streets are snow covered suggests that the dusty streets and the high school parking lot contribute an extraordinary amount of particulate to the air. The suspended particulate loading at the Dehlbom Residence just barely meets the State Standard (Table #16). This sampling site is in a rural location and should show average particulate loading of about 15 mg/m^3. A large amount of the excess particulate is assumed to be emitted by the nearby aluminum plant.

Kalispell Area

Two suspended particulate sampling sites are located in the Kalispell area. Their locations are shown on Map #VI. The high school station is most descriptive of the community as a whole and indicates values of suspended particulate loading in excess of the State Standard (Table #16). Without doubt some of the particulate measured was due to the construction of new school building in the area. The West Evergreen Station is in a suburban area, located upwind from two wood products industries. It also exceeds

the State standard for particulate loading. At both of the Kalispell sampling stations the suspended particulate values drop during the winter months (Table #16). This again suggests that dusty streets are a significant source of airborne particulate.

Libby Area

The location of the two sampling stations in the Libby area are shown on Map #VIII. The Asa Wood School station is the most descriptive of the air quality in the community of Libby. This station exhibits the highest average suspended particulate values ever recorded in the State of Montana. Although dusty streets and construction in the area are certainly extremely important contributors to the suspended particulate of the area, the important contributors to the suspended particulate of the area, the particulate values do not come down drastically in the winter months. Possibly construction work on nearby streets during the winter months contributed to this effect. The station located at the Sprague Residence is in a semi-rural area and with no heavily traveled unpaved roads in the vicinity. The station is downwind from the St. Regis Company, plywood plant, and the excessive particulate collected here (Table #16) is probably attributable to this plant's wood waste burners. Use of "teepee" type burners for disposal of wood waste has since been discontinued at this plant.

Polson Area

The location of sampling stations in the Polson area are shown on Map #VII. Suspended particulate levels (Table #6) in the Polson area are well above the State Ambient Air Quality Standard. The Trussler Residence is rural and most of the excess amount of particulate is emitted by the upwind lumber mill. The Malgren Residence is located in town near the Pack River Plywood Company. The suspended particulate collected at this station is well in excess of the State Standard (Table #16). As in other communities studied the values decrease drastically during the winter months indicating dusty streets as a major particulate contributor. During the spring of 1969 many complaints were received concerning excessive smoke from the Pack River teepee burner. Operation of the burner was discontinued in June of 1969 which is evident in suspended particulate samples taken after that time.

BENZENE SOLUBLE FRACTION OF THE SUSPENDED PARTICULATE

The benzene soluable fraction of a suspended particulate filter is an indicator of the amount of organic matter. Fossil fuels and organic waste release carboniferous particulate and aerosols to the atmosphere, the benzene soluble fraction is an indicator of such burning. Common contributors to the organic fraction are open burning of refuse, slash burning, wood waste burning, automobile emissions and space heating. There is no State Standard for benzene soluble fraction as this information is used primarily to detect possible sources of the particulate collected.

Columbia Falls Area

At the Dehlbom Residence the benzene soluble fraction is extremely high (Table #16) for a rural sampling site. An average rural value for benzene soluble fraction is about 2.5 ug/m^3. The majority of the collected organic is attributed to hydrocarbon emissions from the aluminum plant. Probably a small amount is contributed by local wood products industries and an undetermined amount is contributed by slash burning in the area. The high school and junior high school samples show elevated benzene soluble fractions (Table #16) mostly due to the nearby wood products industries.

Kalispell Area

The Kalispell High School and West Evergreen School show the lowest values for the organic fraction in the study area. This is to be expected because of the location of Kalispell in the valley and the widespread use of natural gas. The West Evergreen School samples are not affected a great deal by the nearby wood waste industries because they are downwind from the sampling site.

Libby Area

Libby has the highest concentrations for benzene soluble fraction in the study area. The local lumber mill certainly contributed to this loading during the study period. Other contributions were made by use of oil and coal for space heating. The entire Libby area is surrounded by slash burning which contributes an undetermined but probably large amount.

Polson Area

The relatively high amount of benzene soluble fraction in the rural area of the Trussler Residence is almost entirely due to the nearby wood waste burner and boilers. Combustion in the boilers has been very inefficient during nearly every visit our staff has made to the area. The large benzene soluble fraction at the Malgren Residence sampling site is assumed to be caused by particulate emissions from the nearby Pack River Plywood Company.

SULFATE FRACTION OF THE SUSPENDED PARTICULATE

The sulfate fraction of the suspended particulate in the study area is a gross indicator of fossil fuel combustion. The State Ambient Air Quality Standard for suspended sulfate is 4 ug/m^3 maximum allowable annual average not to exceed 12 micrograms per cubic meter over 1 percent of the time. Only one of the stations sampled exceeded the State Standard, however, values at Columbia Falls and Libby are very near it (Table #16). The source of suspended sulfate in Columbia Falls at Dehlboms is assumed to be from the aluminum smelter operations. At the Jr. High School station space heating and wood waste burners are probably the largest contributors. In Libby the assumed sources are space heating with contributions from wood waste burning. The excessive sulfate fraction found at the Malgren Residence in Polson (Table #16) exceeds the State Standard. This is attributed to the lack of natural gas in the area for space heating.

LEAD FRACTION OF THE SUSPENDED PARTICULATE

The lead fraction of the suspended particulate was, as expected, low at all sampling stations. The results of lead analyses are listed on Table #16. The State Ambient Air Quality Standard for lead is 5.0 ug/m^3 (micrograms per cubic meter), 30 days average. Reference to Table #16 shows that the values for lead at all stations were below the State Standard.

Comparison of lead concentrations at the Kalispell High School and Columbia Falls High School shows no detectable change in concentration between 1961 and 1969.

ARSENIC FRACTION OF THE SUSPENDED PARTICULATE

Essentially no arsenic was detected in any of the samples analyzed. This is as expected due to the lack of arsenic producing sources in the area. Results of analyses are listed on Table #16.

Burning Dumps are a common sight in the Flathead Valley

TABLE #16
SUMMARY OF MEASURED ATMOSPHERIC CONCENTRATIONS
OF TOTAL SUSPENDED PARTICULATE, BENZENE SOLUBLE
FRACTION, ARSENIC, AND IN THE FLATHEAD VALLEY
1969-1969-1970

Station	Year	Season	No. of Samples	Concentration of Specific Pollutants in Micrograms Per Cubic Meter of Air: Total Suspended Particulate			Benzene Soluble Fraction			% Benzene Soluble			Sulfates			Arsenic			Lead		
				max.	min.	ave.	max.	min.	ave.	max.	min.	ave.	max.	min.	ave.	max.	min.	ave.	max.	min.	ave.
#1 Col. Falls Dehlboms	69-70	Study Period	143	172	8	61	54.5	0.8	8.5	70.1	1.1	18.4	5.8	N.D.	3.1	N.D.	N.D.	N.D.	.07	N.D.	.02
		Mar. Apr. May	11	159	23	67	25.9	0.8	9.5	27.9	3.2	15.6	5.8	1.0	4.3	N.D.	N.D.	N.D.	.07	N.D.	.03
		June July Aug.	22	110	11	64	17.3	1.4	5.9	44.5	4.0	11.5	4.0	N.D.	1.9	N.D.	N.D.	N.D.	.05	N.D.	.01
		Sept. Oct. Nov.	31	158	11	44	25.2	1.6	9.4	70.7	1.1	25.1	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	28	172	11	42	54.5	2.0	12.4	61.7	14.9	30.6		"			"			"	
		Mar. Apr. May	28	144	8	75	17.7	1.7	6.6	38.0	1.6	15.3		"			"			"	
		June July Aug.	23	169	23	73	14.8	1.0	7.0	50.9	3.0	12.0		"			"			"	
#2 Col. Falls High School	69-70	Study Period	104	472	N.D.	151	48.0	N.D.	9.4	72.5	N.D.	10.6	4.5	N.D.	1.8	N.D.	N.D.	N.D.	.13	N.D.	.05
		Mar. Apr. May	4	218	64	140	7.9	2.6	5.3	8.3	2.8	4.4	2.2	.6	1.4	N.D.	N.D.	N.D.	.10	.05	.06
		June July Aug.	19	331	7	157	14.2	.7	6.8	22.6	2.3	5.8	4.5	N.D.	2.2	N.D.	N.D.	N.D.	.13	N.D.	.05
		Sept. Oct. Nov.	25	472	16	165	48.0	5.1	17.0	72.5	2.0	17.1	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	21	439	21	83	43.2	4.7	14.8	58.8	7.4	29.1		"			"			"	
		Mar. Apr. May	28	417	15	163	30.3	.9	7.9	40.9	1.0	4.9		"			"			"	
		June July Aug.	6	470	8	250	8.1	N.D.	5.2	5.6	N.D.	2.1		"			"			"	
#3 Col. Falls Jr. High	69-70	Study Period	129	289	7	124	38.2	0.7	9.5	54.8	0.7	10.1	7.7	0.9	3.0	N.D.	N.D.	N.D.	.21	.01	.06
		Mar. Apr. May	16	283	48	165	16.5	2.9	8.7	15.4	3.1	5.8	7.7	1.8	3.4	N.D.	N.D.	N.D.	.21	.02	.08
		June July Aug.	22	289	7	142	21.8	3.2	9.4	50.0	2.4	9.3	4.3	.9	2.6	N.D.	N.D.	N.D.	.09	.01	.05
		Sept. Oct. Nov.	26	260	20	143	38.2	4.8	16.9	33.3	3.2	13.7	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	19	207	10	55	28.0	.7	11.0	54.8	6.4	21.1		"			"			"	
		Mar. Apr. May	27	271	41	122	17.2	1.1	6.3	24.6	.7	6.2		"			"			"	
		June July Aug.	19	206	26	117	8.2	2.1	4.8	10.4	2.4	4.7		"			"			"	
#4 Kalispell Evergreen	69-70	Study Period	135	301	6	80	22.6	N.D.	6.3	53.2	N.D.	10.7	6.4	N.D.	2.3	N.D.	N.D.	N.D.	.22	N.D.	.06
		Mar. Apr. May	14	158	14	76	7.4	1.5	4.6	31.1	2.6	8.5	6.4	1.2	2.5	N.D.	N.D.	N.D.	.19	.02	.07
		June July Aug.	24	231	6	91	11.6	.1	4.7	14.3	2.5	5.8	4.4	N.D.	2.1	N.D.	N.D.	N.D.	.22	N.D.	.06
		Sept. Oct. Nov.	27	179	9	71	22.6	.4	9.8	53.2	.8	16.6	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	25	169	10	47	17.0	1.8	8.0	33.3	6.9	19.1		"			"			"	
		Mar. Apr. May	21	241	15	88	12.7	.8	5.5	30.2	1.1	8.7		"			"			"	
		June July Aug.	24	301	18	106	17.4	N.D.	5.2	18.5	N.D.	5.4		"			"			"	
#5 Kalispell High School	69-70	Study Period	113	224	5	87	26.4	N.D.	6.4	38.3	N.D.	9.5	8.4	N.D.	2.6	N.D.	N.D.	N.D.	.31	N.D.	.10
		Mar. Apr. May	13	161	26	83	6.0	3.8	5.2	23.5	2.7	8.2	5.4	1.1	2.7	N.D.	N.D.	N.D.	.31	N.D.	.11'
		June July Aug.	23	224	5	100	12.8	N.D.	4.1	13.9	N.D.	4.8	8.4	N.D.	2.5	N.D.	N.D.	N.D.	.28	N.D.	.07
		Sept. Oct. Nov.	27	209	21	86	26.4	2.0	8.8	34.0	1.7	13.1	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	12	151	24	66	16.9	3.3	10.5	32.7	9.4	17.1		"			"			"	
		Mar. Apr. May	29	202	22	93	14.3	2.3	6.5	38.3	2.5	9.9		"			"			"	
		June July Aug.	9	151	33	94	5.9	.8	3.4	4.9	1.9	3.6		"			"			"	
#6 Libby Ass Wood School	69-70	Study Period	130	733	34	243	76.7	1.8	21.3	50.5	0.7	10.8	7.2	0.9	3.9	N.D.	N.D.	N.D.	.33	.02	.14
		Mar. Apr. May	12	375	35	186	30.5	4.6	14.1	42.1	3.0	12.9	7.2	1.2	4.3	N.D.	N.D.	N.D.	.31	.04	.16
		June July Aug.	29	421	34	169	18.9	1.8	9.0	18.8	.7	6.3	5.9	.9	3.4	N.D.	N.D.	N.D.	.33	.02	.13
		Sept. Oct. Nov.	30	517	42	284	50.2	4.8	25.3	36.3	1.5	11.5	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	16	481	50	218	76.7	19.4	38.1	50.5	6.6	25.5		"			"			"	
		Mar. Apr. May	26	733	93	337	74.2	2.9	32.0	15.3	1.2	4.8		"			"			"	
		June July Aug.	17	470	120	261	16.1	2.6	9.4	5.3	2.2	3.7		"			"			"	
#7 Libby Sprague Residence	69-70	Study Period	88	269	23	91	58.8	1.4	10.8	47.3	0.7	13.5	4.5	N.D.	2.8	N.D.	N.D.	N.D.	.36	.03	.14
		Mar. Apr. May	14	183	32	84	14.1	4.1	6.8	46.6	2.6	13.0	4.1	1.0	3.2	N.D.	N.D.	N.D.	.36	.06	.16
		June July Aug.	25	189	23	82	17.0	1.9	6.8	23.0	.7	9.0	4.5	N.D.	2.3	N.D.	N.D.	N.D.	.32	.03	.12
		Sept. Oct. Nov.	17	269	37	100	58.8	4.5	18.1	34.8	6.1	17.5	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	12	162	30	82	38.4	10.0	20.5	47.3	14.3	27.2		"			"			"	
		Mar. Apr. May	15	227	43	104	26.9	1.4	7.6	25.1	2.3	8.6		"			"			"	
		June July Aug.	5	165	65	97	6.4	3.8	5.2	9.1	3.3	5.9		"			"			"	
#8 Polson Malgren Residence	69-70	Study Period	85	416	10	109	37.4	2.8	10.7	97.7	2.1	15.0	15.6	0.3	4.6	.002	N.D.	.002	.39	.03	1.1
		Sept. Oct. Nov.	29	174	10	68	18.7	2.8	8.7	97.7	5.5	22.8	8.9	0.4	3.6	N.D.	N.D.	N.D.	.39	.04	1.4
		Dec. Jan. Feb.	5	79	25	53	19.5	7.6	12.8	38.5	17.4	26.8	11.4	2.6	6.9	N.D.	N.D.	N.D.	.24	.05	.12
		Mar. Apr. May	18	416	42	170	37.4	5.9	14.9	26.6	2.1	10.3	15.6	3.3	6.4	N.D.	N.D.	N.D.	.28	.04	.11
		June July Aug.	23	238	45	138	11.9	3.0	6.2	9.4	2.3	4.8	3.8	0.3	1.5	.002	.002	.002	.09	.03	.05
		Sept. Oct. Nov.	10	225	44	115	22.4	4.2	10.9	17.2	4.2	10.6	Discontinued			Discontinued			Discontinued		
#9 Polson Trussler Residence	69-70	Study Period	103	311	12	71	44.8	2.0	6.9	78.9	0.3	11.1	4.9	N.D.	2.4	N.D.	N.D.	N.D.	.23	N.D.	.07
		Mar. Apr. May	12	143	43	93	12.9	3.3	7.3	22.6	.9	8.4	4.9	1.1	2.8	N.D.	N.D.	N.D.	.23	.03	.10
		June July Aug.	24	311	32	141	19.7	2.4	6.8	10.2	.3	3.8	4.0	N.D.	2.0	N.D.	N.D.	N.D.	.16	N.D.	.0[illegible]
		Sept. Oct. Nov.	27	191	12	84	44.8	3.2	10.9	78.9	.5	19.0	Discontinued			Discontinued			Discontinued		
		Dec. Jan. Feb.	16	109	20	47	17.9	4.4	9.7	40.0	9.1	22.2		"			"			"	
		Mar. Apr. May	24	150	13	58	18.1	2.0	6.8	32.7	.4	13.4		"			"			"	
		June July Aug.																			

REPORT TO MONTANA STATE DEPARTMENT OF HEALTH ON EFFECTS OF SMELTER EMISSIONS AT COLUMBIA FALLS, MONTANA

C. C. Gordon
Department of Botany
University of Montana
January, 1970

Introduction

During the summer of 1969 the effects of emissions from the Anaconda aluminum smelter at Columbia Falls were studied. These studies included effects on indigenous conifers, rodent populations, and grasses and on lettuce from local gardens. Previous studies had indicated that smelter emissions, specifically hydrogen fluoride, were damaging vegetation for several miles around the smelter. The 1969 study was designed to determine the nature of the causal agent of the plant damage, the geographical extent of this damage, and possibly disruptions in indigenous animal populations as a consequence of plant damage. The possible health hazard to humans from eating vegetables grown in the smelter fumes was also investigated.

The study was composed of several parts. One was the histological study of conifer needles to determine the causal agent of the damage evident. The second was the chemical analysis of grasses, lettuce, conifer needles, and rodent femurs. The third part was a feeding study of rabbits with lettuce grown where smelter emissions were present. Figure 1 shows the collection sites for animals and vegetation near Columbia Falls.

Methods and Materials

Histological Studies. Needles were collected and sectioned from five conifers growing in the Columbia Falls area. The needle sections were prepared by the paraffin method, cut at thicknesses of 12 and 15 micra and stained with Feulgen's solution and fast green. Sections were studied with a Reichert phase microscope and photographed in color with Leitz-Wetzlar photomicrograph equipment.

Chemical Analysis of Fluoride. Lettuce was collected from ten gardens in the vicinity of the smelter for analysis for fluorides. The collections were made on six days from June 26 to August 20. Controls were taken from two Missoula gardens. The lettuce was placed in plastic bags in the field and a portion removed in the lab to be sent for analysis. Analysis for fluorides was done at the WARF, Inc. laboratory in Madison, Wisconsin. The method used is that reported in the A.O.A.C., 10th Ed. (1965), p.360.

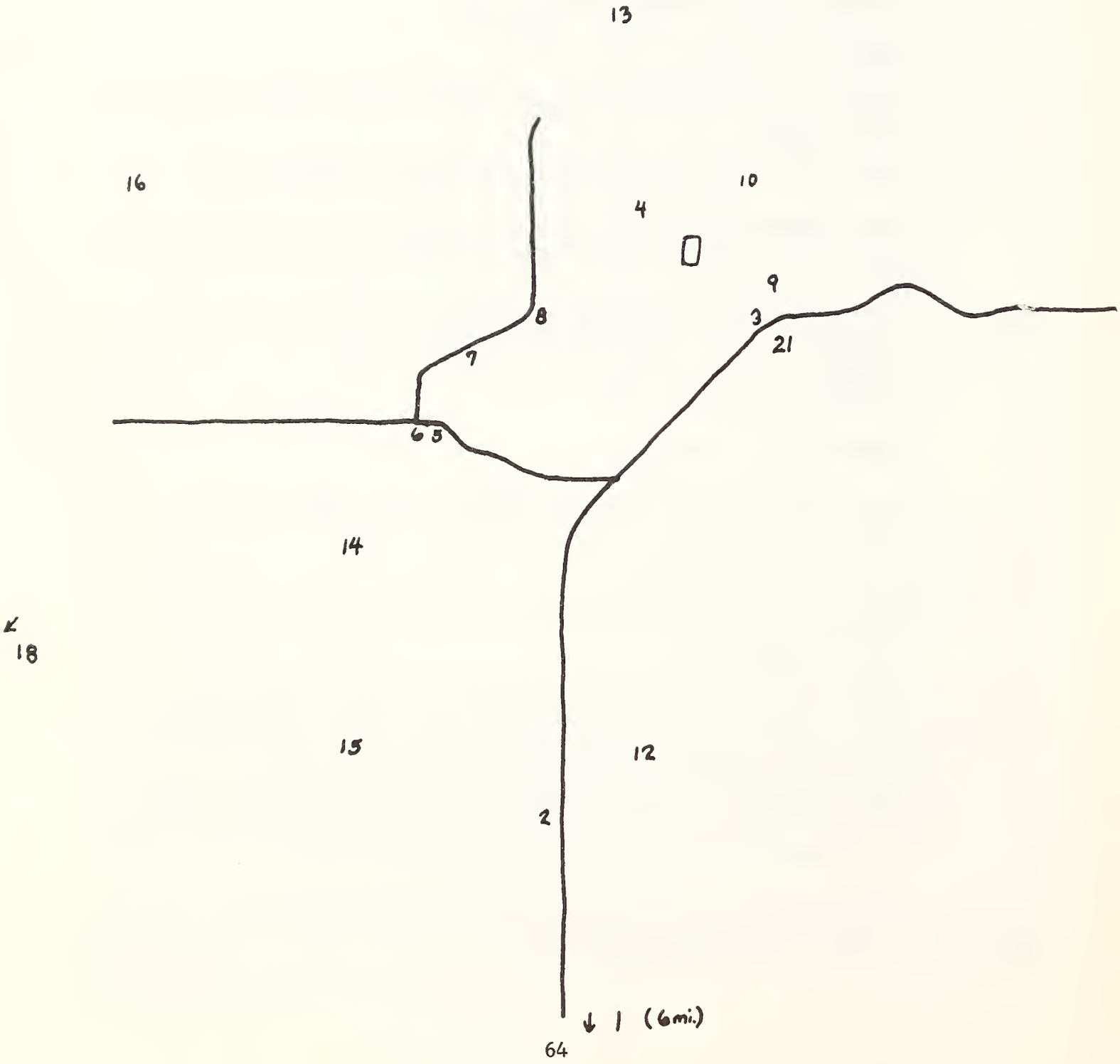
Grass samples (including alfalfa and clover) were collected at nine sites near the smelter for fluoride analysis. In most cases the sample was of mixed grasses with some 1968 stalks mixed with the 1969. Collections were made on four dates from June 26 to September 19. Analyses were done by WARF, Inc. as for the lettuce.

COLUMBIA FALLS COLLECTION SITES
1969

Site #	Description
1	Twelve miles south of Columbia Falls at Y to be used as controls
2	One-half mile north of Trap Cafe, 3 miles south from the Columbia Falls turnoff before Bad Rock Canyon
3	Straight across the river from the aluminum plant where the pictures were taken of Teakettle Mt.
4	Big field next to the aluminum plant
5	Hungry Horse News
6	Schneider, from garden located one block west of the Hungry Horse News building
7	Bibb, Victor, 555 6th Avenue, in northeast Columbia Falls
8	Ralph Johnson, East Railroad Street, which is just prior to going across the railroad tracks where we go down to get to Teakettle Mt.
9	On a little knoll overlooking the aluminum plant at the end of the road
10	Teakettle Mountain
11	Hughes Garden, Missoula
12	Roger, approximately 4½ miles south of the aluminum plant
13	Sedivy
14	Tom Little
15	Buck's Garden
16	Loren Frerich, one block north of Stoltz Lumber (Half Moon)
17	University of Montana Botany Garden, Missoula
18	Aenard Johnson, on old Whitefish road, 8 miles from the plant
19	Cox, Blankenship Bridge, 0.7 miles from the bridge
20	Glacier Park at junction of Middle Fork and North Fork
21	1½ miles from the aluminum plant

Figure 1a

COLUMBIA FALLS COLLECTION SITES
1969



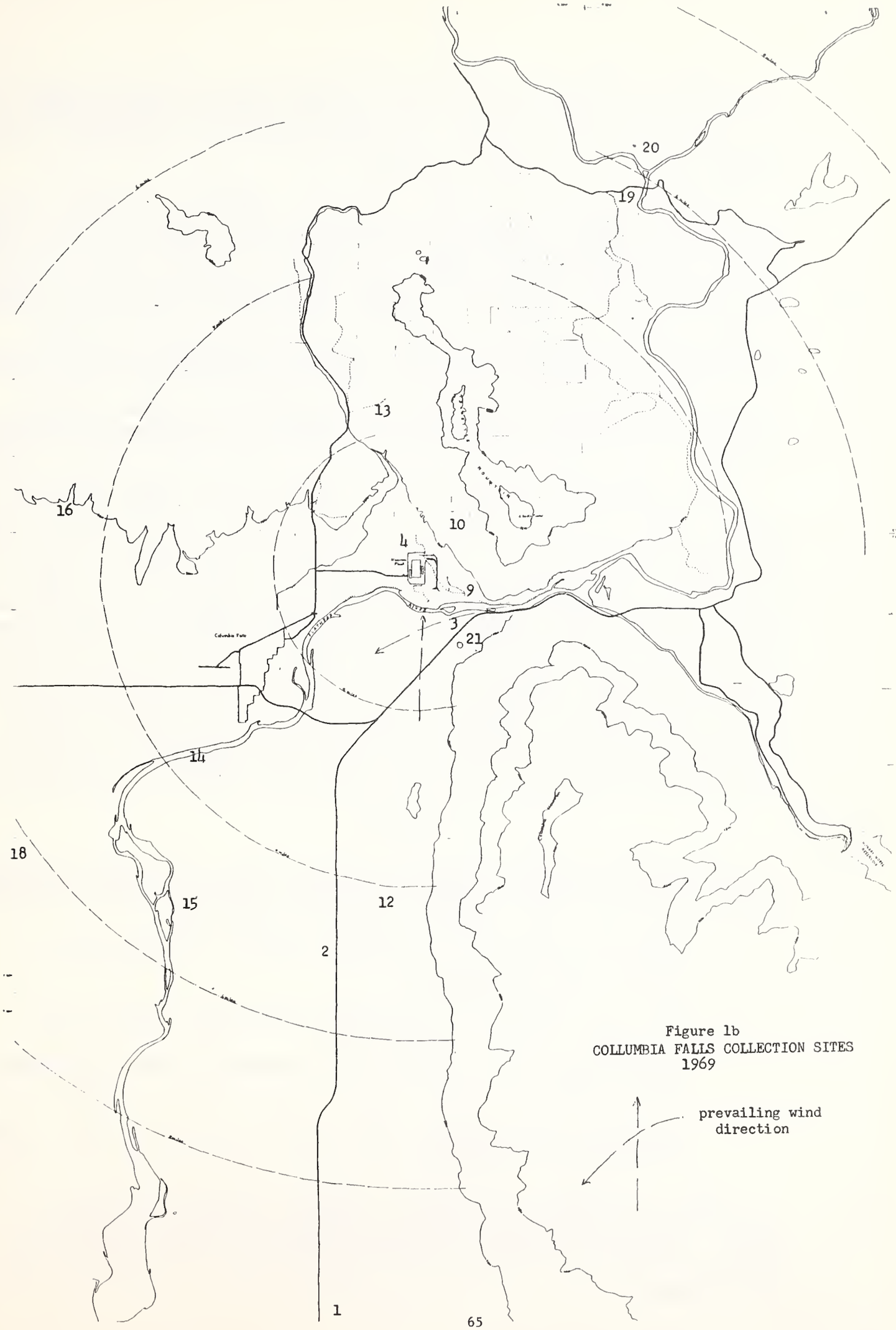


Figure 1b
COLLUMBIA FALLS COLLECTION SITES
1969

Conifer needles were collected from ten trees at five sites for fluoride analysis. Five conifer species were included, and both 1968 and 1969 needles were analyzed for three trees. Branches were placed in plastic bags in the field and needles were removed from the branches in the laboratory. Fluoride analysis was as for lettuce and grasses.

An extensive rodent trapping program was conducted around the smelter, particularly on the southwestern slopes of Teakettle Mountain (at the base of which the smelter is situated). Details of the rodent trapping program (including species trapped, trap sites, and dates of collection) are reported in "Columbia Falls Study, Summer, 1969" * by Joe and Carole Elliott. Of the 150 animals collected eight were selected for fluoride analysis of the femur bones. To obtain the minimum weight required for analysis, both femurs were used as the sample. Femurs were removed from all animals and packaged in brown paper bags for future analysis. Collection data includes sex and maturity and presence of embryos in females. Control animals were obtained from MacDonald Pass (150 miles southeast of Columbia Falls).

Four rabbits were fed lettuce from Columbia Falls gardens for six weeks. Lettuce for this feeding study was obtained from two gardens (Johnson and Schneider) at weekly intervals and brought to Missoula in plastic bags. This lettuce was stored in a cooler and delivered twice weekly to Mr. B. Rewey who was caring for the rabbits. A control group of four rabbits was fed lettuce from Hughes Gardens in Missoula. Two rabbits were housed in each pen and the daily ration of Seretana rabbit feed pellets (86.6 grams) and of lettuce (100 grams) was placed in each pen. Rabbits were within a few days of being nine weeks old at the start of the feeding study and were fed for six weeks. Lettuce from the two Columbia Falls gardens and from Hughes Gardens and the Ceretana feed were analyzed for fluoride content. When the rabbits were sacrificed, the livers and kidneys were packaged separately in plastic bags and frozen within the body cavity of the rabbit. One femur from each animal was removed and sent to WARF for fluoride analysis.

Results

Histological Studies of Conifer Needles. The needle tissues from the Columbia Falls collections exhibit the disease syndrome typical of hydrogen fluoride exposure. These symptoms include the following:

1. Mesophyll cell beneath the stomata does not collapse as in sulfur dioxide fumigation;

2. The active phloem cells die prior to the older phloem cells;

3. Hypertrophy occurs throughout the parenchyma of the transfusion tissue; and

4. Hypertrophy of epithelial cells of the resin canals occur, causing occlusion of the canals.

Chemical Analyses of Fluorides. Results of fluoride analyses of lettuce from Columbia Falls gardens are shown in Figure 2 and Table I. Figure 2 indicates fluoride in parts per million on a map overlay, relating concentration to distance and direction from the aluminum smelter.

*See Appendix A

Concentration of fluorides in grasses is shown in Table II and is related to distance and direction from the aluminum smelter in Figure 3.

Results of the fluoride assay of conifer needles are listed in Table III and compared in Figures 4, 5, and 6. Figure 4 shows the fluoride concentration in several conifer needle collections as related to distance and direction from the smelter. Figure 5 gives a comparison of accumulation of fluorides by 1969 needles of four conifer species at the same site. Figure 6 lists the tree collections where both 1968 and 1969 needles were analyzed, comparing 1968 and 1969 levels of fluorides.

Data for the eight rodents selected for femur fluoride analysis is shown in Table IV along with a control sample from MacDonald Pass.

Results of the six week rabbit feeding study are listed in Table V. Besides the WARF analyses, analyses (using two variations) were run on several duplicate bone samples at this laboratory with the Orion fluoride ion meter and these results are also listed in Table V.

Figure 2

COLUMBIA FALLS LETTUCE COLLECTIONS
(ppm fluoride, dry weight basis)
1969

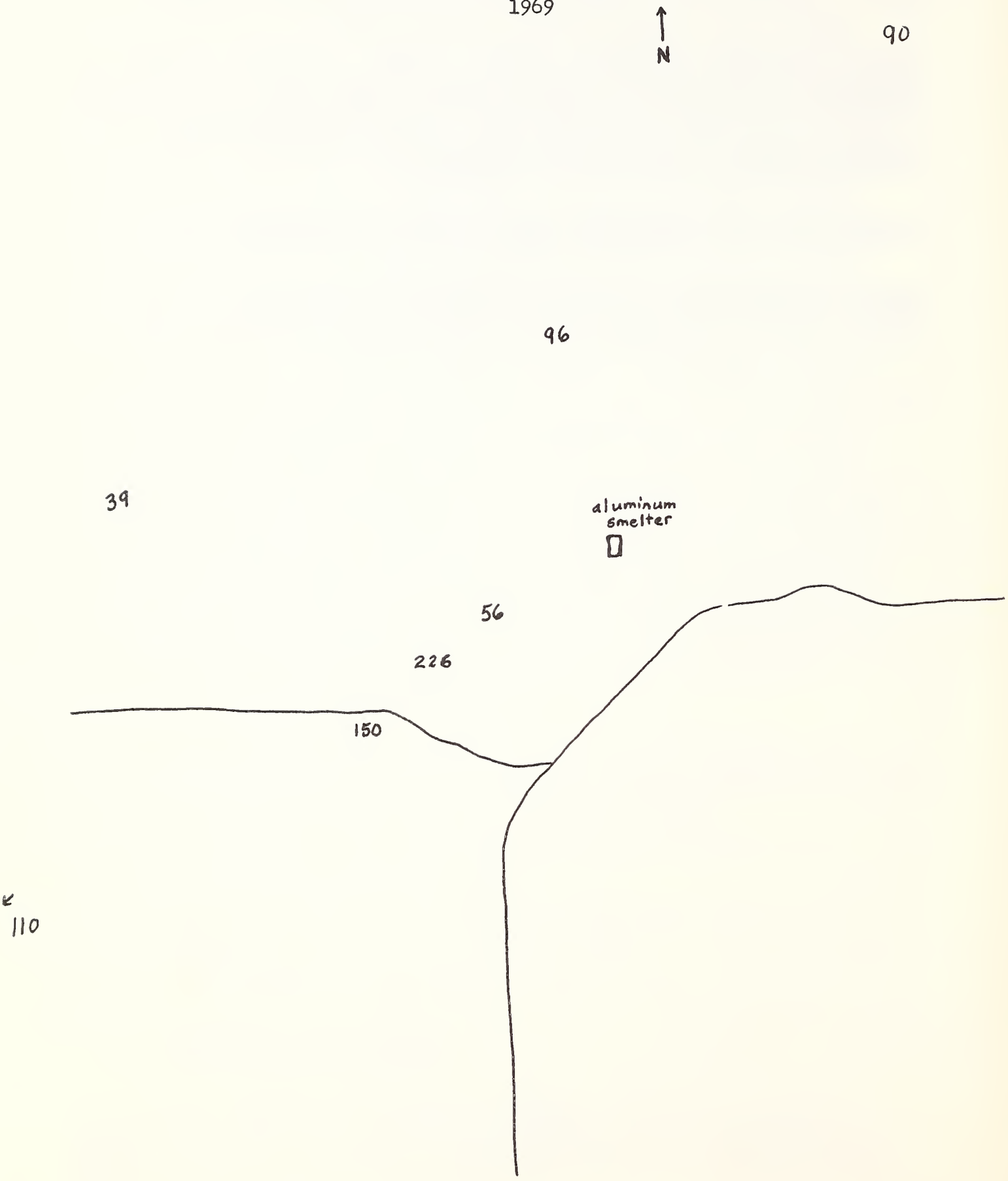


TABLE I

COLUMBIA FALLS LETTUCE* COLLECTIONS
(ppm fluoride, dry weight basis)
1969

Site #	Date	Sample Code #	Specimen	F in ppm
13	7/14/69	CF-gl	Lettuce	96
11	8/13/69	CFC-1**	Lettuce	24
15	8/12/69	CF-32	Cabbage	18
16	8/10/69	CF-33	Lettuce	39
6	8/12/69	CF-34	Lettuce	75
17	9/3/69	CFC-2***	Lettuce	80
18	9/3/69	CF-35	Lettuce	110
1	6/26/69	CF-1	Wheat	8.1
6	6/26/69	CF-6-A	Cabbage	80
6	6/26/69	CF-6-B	Lettuce	150
7	6/26/69	CF-7	Lettuce	226
8	6/26/69	CF-8	Lettuce	56
19	8/20/69	CF-37	Lettuce	90

* Lettuce and other garden vegetables
** Control, Hughes Garden, Missoula
*** Control, University of Montana Botany Garden, Missoula

Table II

COLUMBIA FALLS GRASS COLLECTIONS
(ppm fluoride, dry weight basis)
1969

Site #	Date	Sample Code #	Specimen	F in ppm
20	9/18/69	DCF-7	Grass & Clover	35
21	7/14/69	CF-24	Grass Composite	21
12	7/14/69	CF-26	Alfalfa	30
13	7/14/69	CF-g2	Alfalfa	36
21	6/28/69	CF-23	Grass Composite	
12	6/28/69	CF-25	Grass Composite	
2	6/26/69	CF-2	Mixed Grasses	12.9
3	6/26/69	CF-3	Mixed Grasses	15.1
4	6/26/69	CF-4-G	Mixed Grasses	115
5	6/26/69	CF-5-G	Mixed Grasses	145
9	6/26/69	CF-9	Clover	70

Figure 3

COLUMBIA FALLS GRASS COLLECTIONS
(ppm fluoride, dry weight basis)
1969

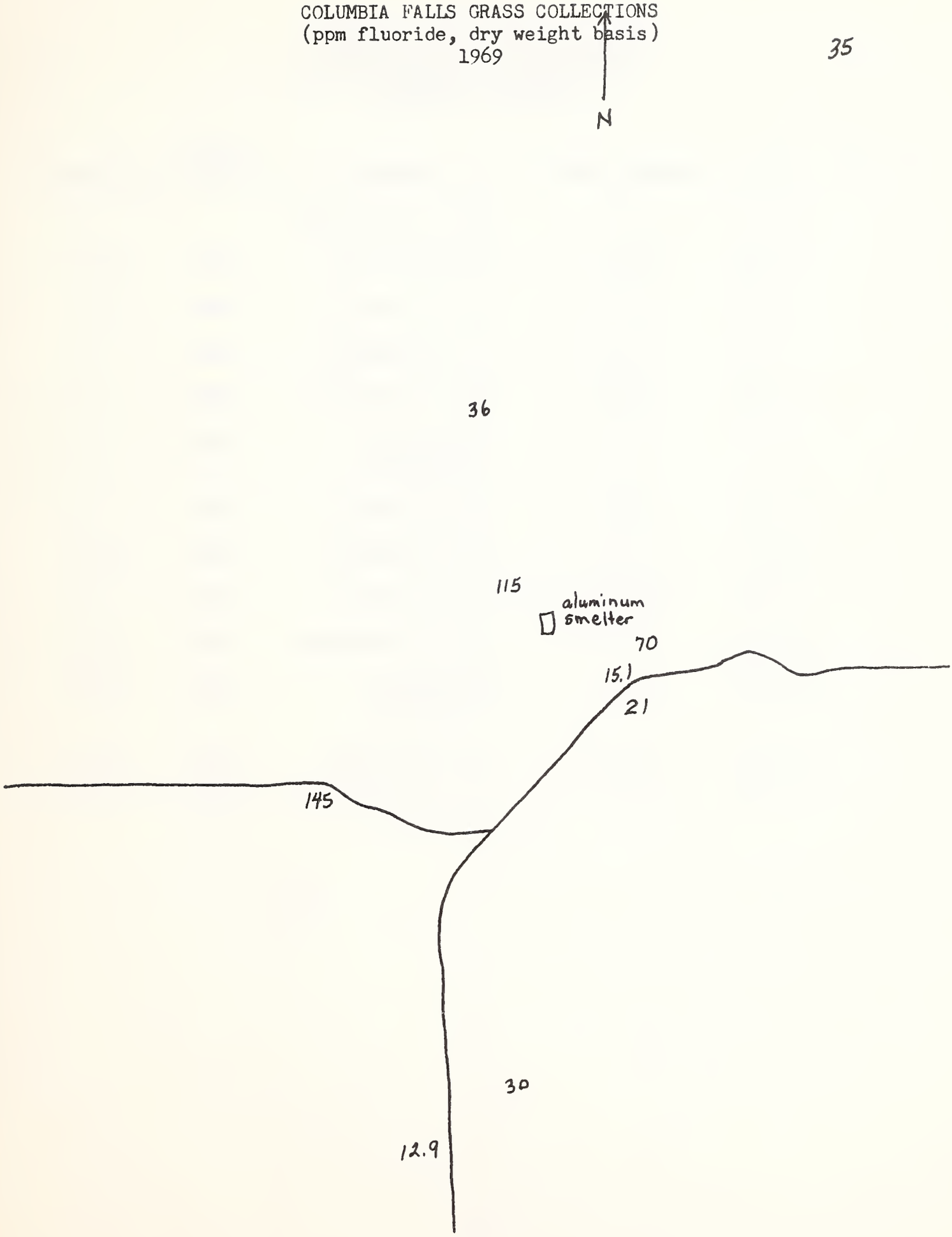


Table III

COLUMBIA FALLS CONIFER NEEDLES
(ppm fluoride, dry weight basis)
5 species of conifers

Site #	Date	Sample Code #	Species	Needle Year	F in ppm
20	9/18/69	DCF-1	Larix occidentalis		50
20	9/18/69	DCF-4	Pinus contorta	1969	400
20	9/18/69	DCF-10	Pinus contorta	1968	425
14	7/14/69	CF-g3	Pinus ponderosa	1969	37
14	7/14/69	CF-g4	Pinus sylvestris	1969	43
14	7/14/69	CF-g5	Pseudotsuga menziesii	1969	51
4	6/26/69	CF-4-A	Pinus ponderosa	1969	33
4	6/26/69	CF-4-B	Pinus ponderosa	1968	290
4	6/26/69	CF-4-C	Pinus contorta	1969	78
4	6/26/69	CF-4-D	Larix occidentalis	1969	114
4	6/26/69	CF-4-E	Pseudotsuga menziesii	1969	150
5	6/26/69	CF-5-A	Pinus ponderosa	1968	125
5	6/26/69	CF-5-B	Pinus ponderosa	1969	24

Figure 4

COLUMBIA FALLS CONIFER NEEDLES
(ppm fluoride, dry weight basis)
5 species of conifers
1969 needles

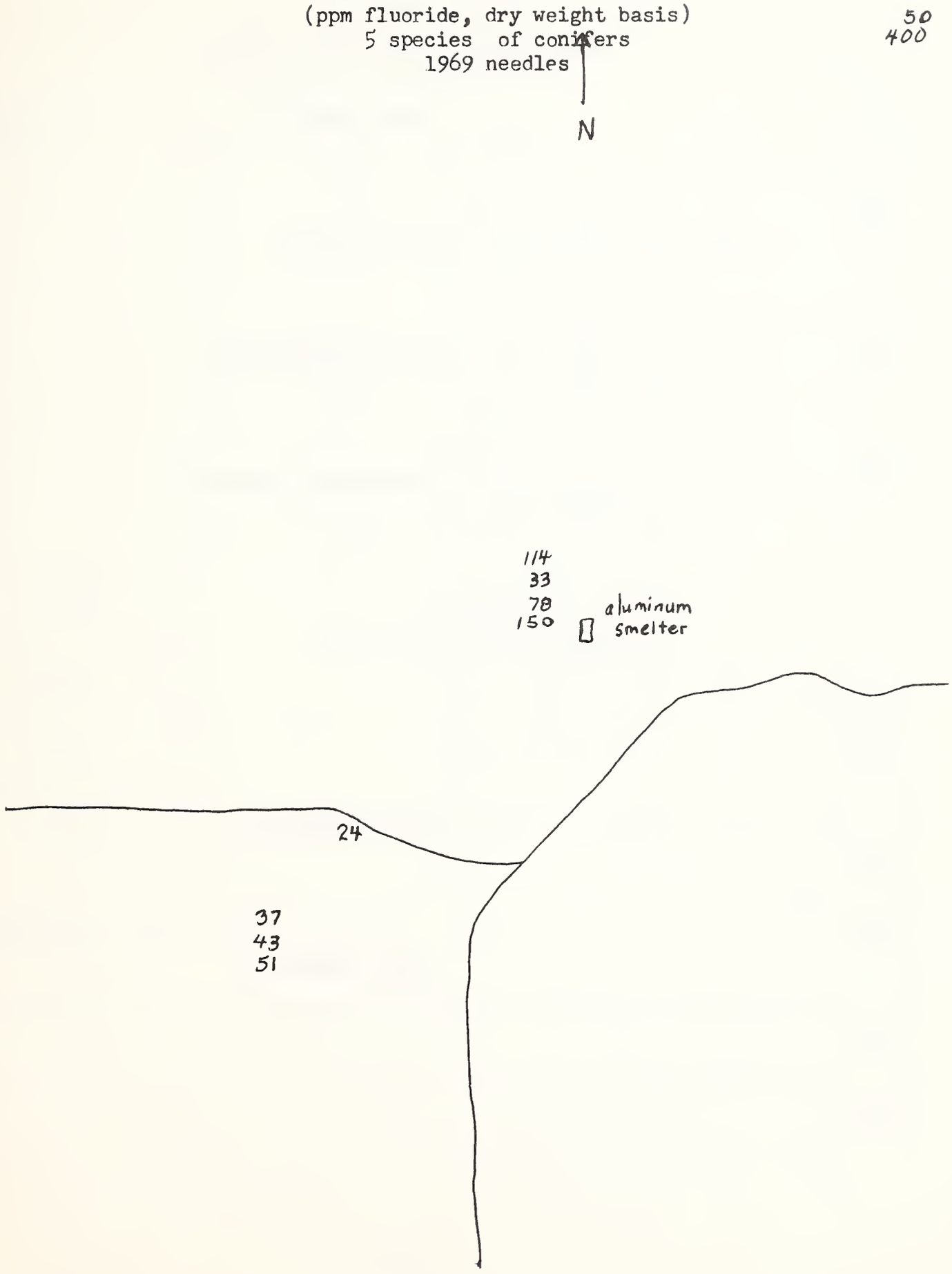


Figure 5

SITE 4 CONIFER COLLECTIONS
(Comparison of 4 species)
1969 needles

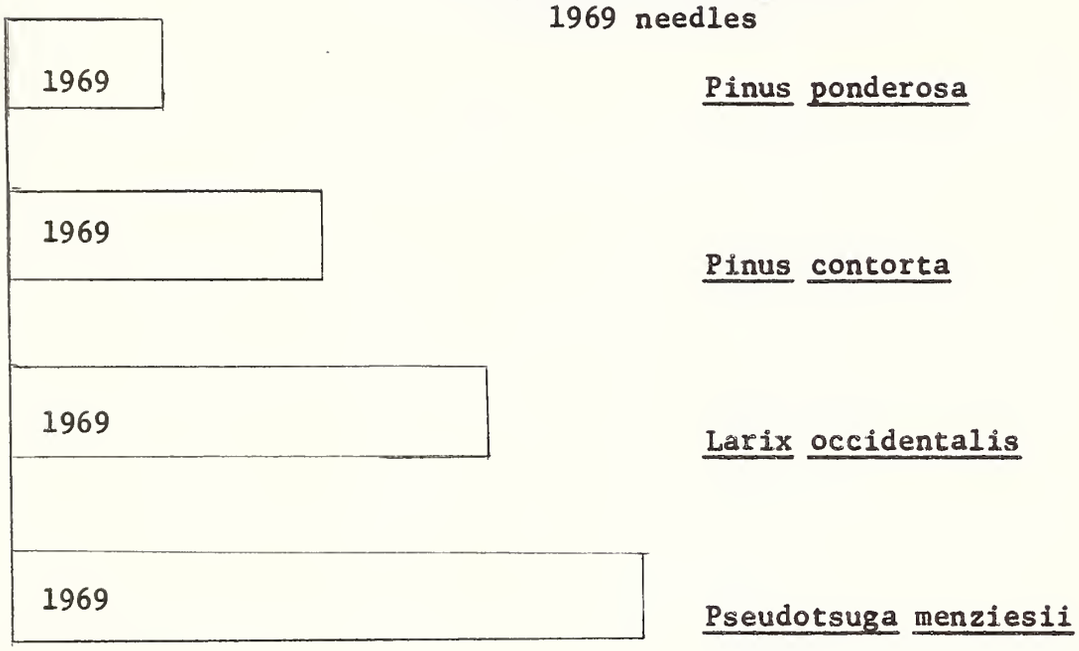


Figure 6

1968-1969 NEEDLE COMPARISON

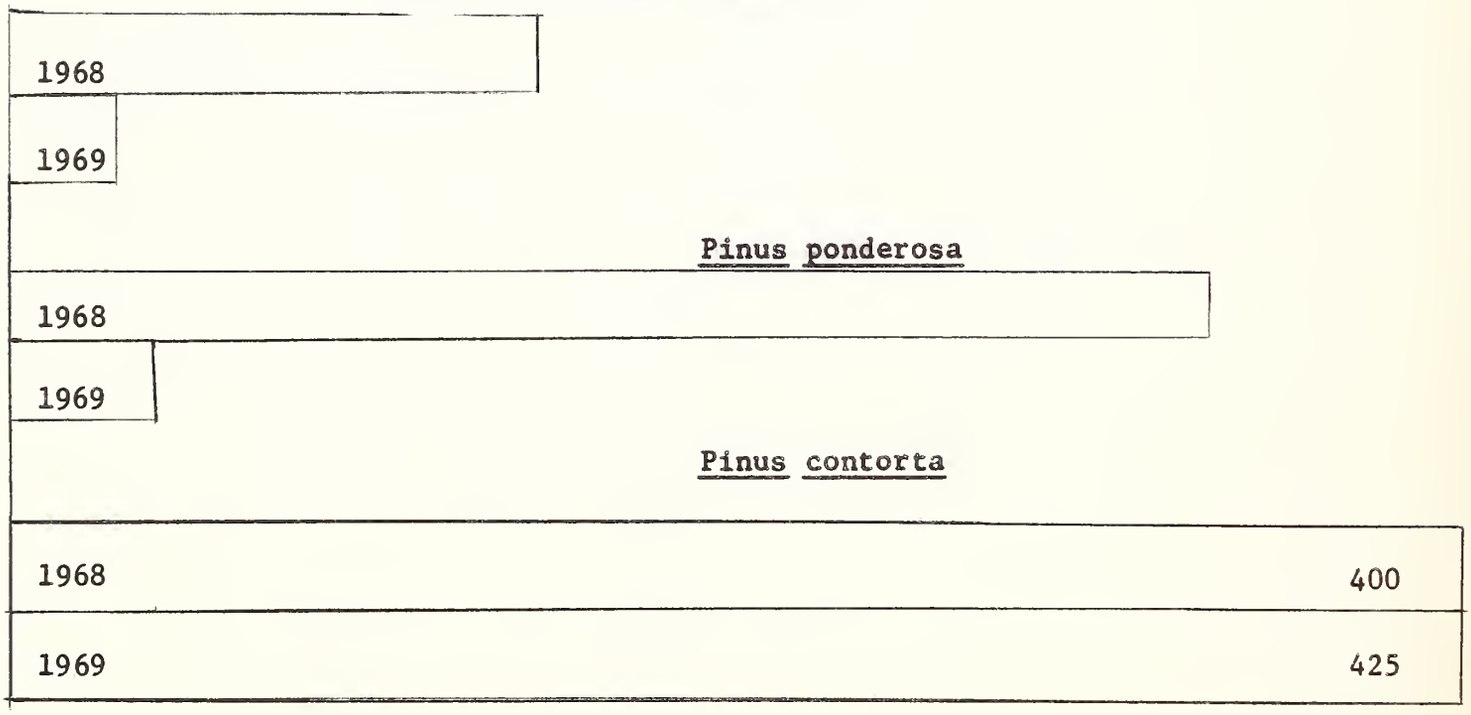


Table IV

Columbia Falls Rodent Collections
(ppm fluoride, dry weight basis)

Collection Site #	Date	Code #	Species	Bone	F in ppm
10	7-5-69	CF-56A	*Citellis columbianus*	Femur	4900
10	7-5-69	CF-57A	*Peromyscus maniculatus*	Femur	4400
10	7-5-69	CF-58A	*Peromyscus maniculatus*	Femur	3900
10	7-5-69	CF-60A	*Peromyscus maniculatus*	Femur	1900
10	7-5-69	CF-61A	*Peromyscus maniculatus*	Femur	4900
10	7-5-69	CF-62A	*Peromyscus maniculatus*	Femur	4400
10	7-5-69	CF-63A*	*Peromyscus maniculatus*	Femur	2300
10	7-5-69	CF-64A**	*Peromyscus maniculatus*	Femur	4700
MacDonald Pass	7-69	15A	*Citellis columbianus*	Femur	140
MacDonald Pass	7-69	15B	*Citellis columbianus*	Femur	260
MacDonald Pass	7-69	15C	*Citellis columbianus*	Femur	230
MacDonald Pass	7-69	15D	*Citellis columbianus*	Femur	220

*2 nipples, enlarged man. gl. dev., 1 emb.
**man. gl. dev., 1 nipple enlarged

Table V

COLUMBIA FALLS RABBIT FEEDING STUDY
Summer, 1969

Code #	Date	Bone	F in ppm (dry weight)			Lettuce Source
			WARF	F ion meter		
				A	B	
R 5c	9-2-69	Femur	220			Botany garden
R 6c	9-2-69	Femur	240			Botany garden
R 7c	9-2-69	Femur	240			Botany garden
R 8c	9-2-69	Femur	360			Botany garden
R 13c	9-2-69	Femur	400	500	390	Columbia Falls
R 14c	9-2-69	Femur	400	390	290	Columbia Falls
R 15c	9-2-69	Femur	250			Columbia Falls
R 16c	9-2-69	Femur	260			Columbia Falls

Kinraid, F ion meter
A = Double std.
B = Addition std.

Discussion

Histological Studies of Conifer Needles. Results of histological studies show conclusively that fluoride concentrations present in conifer needles are causing damage to the tissues. The damage apparent in the conifers surrounding the smelter is the consequence of fluoride effects on the plant tissues. These effects are also occurring in trees which as yet show no visible damage.

Chemical Analyses. Lettuce. Concentrations of fluorides in lettuce varied greatly and were not directly related to distance from the smelter (Figure 2). Both control samples were in the same concentration range as the Columbia Falls lettuce collections (24 and 80 ppm). Thus, it is apparent that atmospheric hydrogen fluoride is not the only contributor to the soil. A possible source of fluoride is fertilizers. Appendix B lists fertilizers available in Missoula giving the percent of fluoride present. Application of such fluoride-containing fertilizers increases the soluble fluoride content of the soil which can be absorbed by the roots causing an increase in plant fluoride. Fluorides usually present in soil are bound in forms which are not absorbed. Since no atmospheric fluorides occur in the Missoula Valley where it was grown, the 80 ppm fluoride in lettuce from the University of Montana Botany Garden is due solely to soluble soil fluoride. Although a contributing factor, hydrogen fluoride from the Anaconda Aluminum Company smelter is not the sole source of fluoride in the lettuce collections.

Grass. The highest concentrations of fluoride in grasses was in the sample from the grounds of the Hungry Horse News in Columbia Falls. The use of fertilizers must be considered as one possible source in this sample. The other grass samples were field samples where the application of fertilizer would be unlikely. Thus, the grass samples probably provide a more accurate picture of contamination by airborne fluorides. The wind patterns for the area (Figure 7) suggest that areas to the north and to the southwest are more heavily dosed with smelter emissions, so that the 115 ppm just northwest of the smelter is as expected. In five of the seven grass samples, the state maximum limit of 35 ppm fluoride in forage is reached or exceeded.

Conifer Needles. Comparison of four species of conifers from the same collection site shows that the four species differ markedly in fluoride accumulation rates. Whether this difference is due to physiological differences or to amount of needle surface was not determined.

Of the three 1968-1969 needle comparisons, Pinus contorta showed little difference. Both trees of Pinus ponderosa show a much higher fluoride content in 1968 than in 1969 needles. These needle collections were made when the 1969 needles were approximately three weeks old. The Pinus contorta at site 20 (Glacier National Park) was several times higher than at site 4, the sampling site closest to the smelter. It would appear that wind during May and June carries the smelter emissions in a northeasterly direction through the saddle of Teakettle Mountain to the Glacier Park area. This coincides with the most active growing period of the newly emerged conifer needles. Also, the site 4 collections were made when the needles had been exposed three weeks, while site 20 needles had been exposed almost 4 months.

Rodents. The concentrations of fluoride in femurs of rodents trapped on the southwestern slope of Teakettle Mountain are evidence that the environment in which these animals live is heavily contaminated with fluorides. Rodent femurs in the Garrison, Montana, area had fluoride concentrations up to 2710 ppm, with most values around 2000 ppm. A normal fluoride level in roden femurs is 250-300 ppm. The Columbian ground squirrel femurs from MacDonald Pass (an area free from fluoride pollutants) had fluoride levels from 140 to 260 ppm.

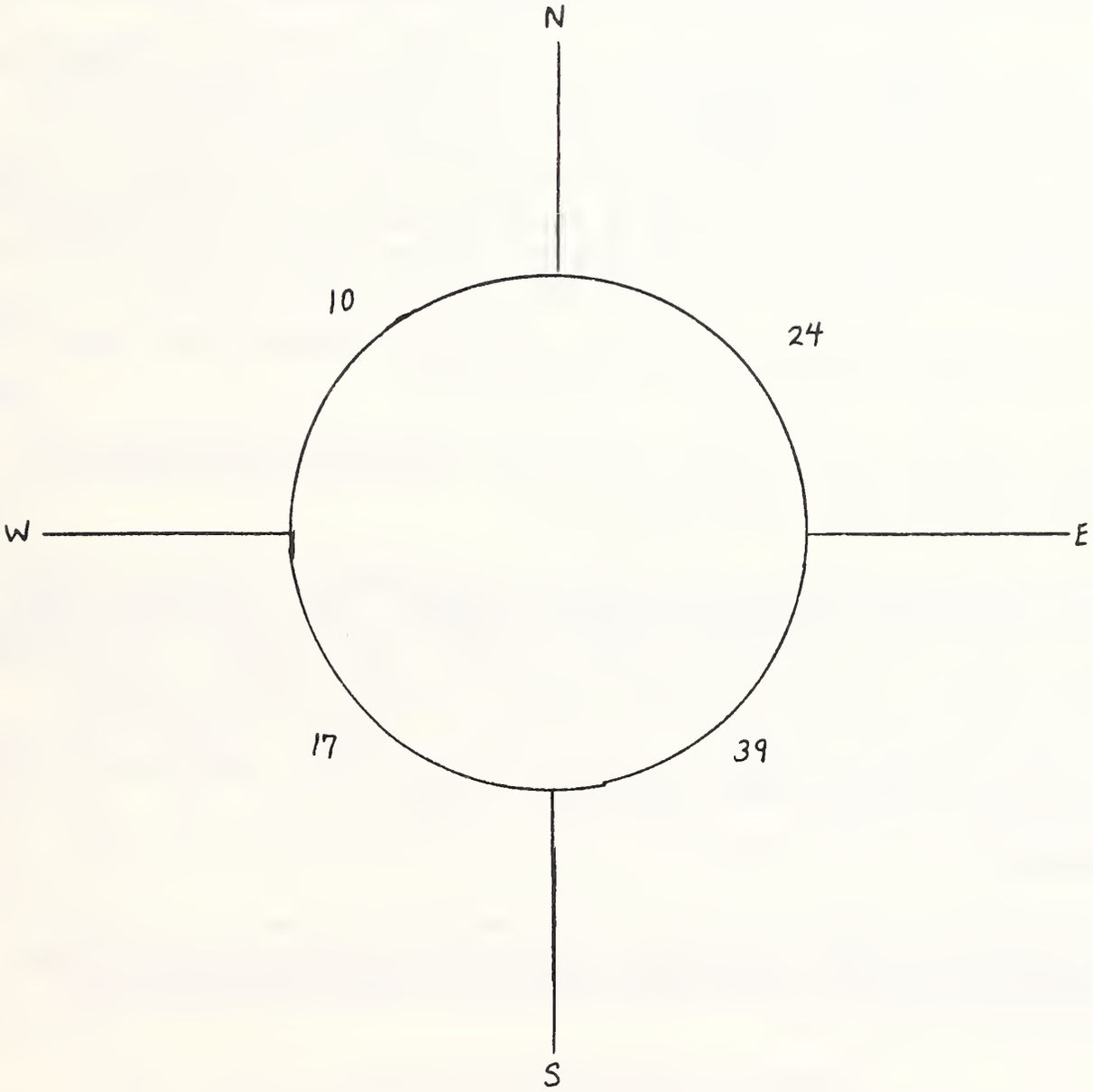
Rabbit Feeding Study. Since the two groups of rabbits were fed lettuce with approximately equal amount of fluoride (Columbia Falls, 56 ppm and 75 ppm and Missoula Botany Garden, 80 ppm), no real difference in fluoride accumulation would be expected. Considering only the WARF analytical data, values for the two groups are similar. One factor which may have had considerable influence on this study was the variability of fluoride content in lettuce collections from one garden over a period of several months.

The preliminary testing of the Orion fluoride meter in matching WARF data gave disappointing results. Evidently the technique selected is very important as far as comparing results. For the Orion techniques, triplicate analyses were close, so that either technique, if consistently used, would provide a basis for comparison, as with the WARF technique. With either Orion technique, the rabbit R-13 has 100 ppm more fluoride in the femur than rabbit R-14. This difference is not shown with the WARF technique where both R-13 and R-14 femurs had 400 ppm.

Of the time and money allotted to the Columbia Falls study in the summer of 1969, most was spent becoming familiar with the area, traveling throughout the region and making contact with residents. The most extensive survey done was the rodent trapping in the smelter vicinity, but limited funds allowed only a small fraction of this rodent collection to be analyzed. Certainly, analysis of the total collection must be made and more extensive collection made of grasses, confiers, and garden vegetables. Femurs from several deer from near the smelter are to be analyzed this winter when conditions permit collection of the animals and the results will be relayed upon receipt.

Figure 7

WIND DIRECTION, DAILY RESULTANT DIRECTION
April, May, June, 1969
Readings at Glacier Park International Airport
Kalispell, Montana



Wind Speed Range
1.7 - 17.8

APPENDIX A

COLUMBIA FALLS STUDY
Summer, 1969

Joe and Carole Elliott

Trapping small rodents was undertaken in the Columbia Falls area during the summer of 1969.

Materials and Methods

Location selected was biased to catch mostly *Microtus* and *Citellus*; the majority of trapping was done in open fields and adjacent to them.

Small and large size snap traps were used for all trapping. They were baited with a mixture of peanut butter and rolled oats. Trap sites were marked with surveyors' flagging. At each location traps were placed at irregular intervals, at signs of animals living there. For example, in *Microtus* habitat traps were placed near piles of grass cuttings and near small burrows. The biased spacing of traps probably increased captures but it eliminates the possibility of comparing densities and species present in the different locations.

No trapping schedule was followed. When the traps were set, they were either checked and reset or picked up the following day.

When animals were captured, vegetation samples were collected at the same location. Other samples were collected from apparently damaged plants at various places in the Columbia Falls area.

All animals captured were brought to the University of Montana Biological Station at Flathead Lake, where they were weighed, their age and sex determined, reproductive condition noted, and the femurs removed. The femurs were placed in a brown paper sack per specimen, and a tag with the above information was attached. The information was also recorded on a data sheet.

During the study relevant conversation with people, trapping locations, and the daily activities were recorded in a diary.

Results

Trapping was conducted with various numbers of traps for 13 nights, giving a total of 1,565 trap-nights. Eleven different locations were used. One hundred forty-two animals were trapped, and eight were obtained by shooting or as road kills.

Summary of All Animals Collected

Peromyscus maniculatus	30
Microtus pennsylvanicus	78
Microtus montanus	15
Citellus columbianus	24
Eutamias reficaudus	1
Eutamias amoenus	2
Total	150

COMMENTS ON COLLECTION WORKSHEETS

ANIMALS

Abbreviations

P. maniculatus = Peromyscus maniculatus		deer mouse
M. pennsylvanicus = Microtus pennsylvanicus		meadow vole
M. montanus = Microtus montanus		mountain vole
C. columbianus = Citellus columbianus		Columbian ground squirrel
E. ruficaudus = Eutamias Ruficaudus		redtail chipmunk
E. amoenus = Eutamias amoenus		Yellowpine chipmunk

Collections Sites

The collection sites briefly described on the worksheets are marked on maps given in Dr. Gordon's report. Mileage from AAC is direct air distance from the center of the existing plant.

Dates

All dates are from 1969.

Aging

For all species, animals were placed in one of three categories: juvenile, subadult, or adult. These categories generally reflect sexual maturity, and have different chronological values for each species.

Peromyscus maniculatus: Juvenile = from about 18 days, when they leave the nest, to six weeks. Juvenile pelage is gray. Subadult = from 6 weeks to ten weeks. During this time the gray pelage is molting to brown. Adult = ten weeks and older. Adult pelage is brown. They rarely live more than two years in the wild. They may breed as subadults, but since pelage colors and molts are distinct and are the usual criteria for aging deer mice, they were used in this study.

Microtus pennsylvanicus and Microtus montanus: Aging was based solely on reproducting condition and size since pelage color does not change during maturation.

Juvenile. These are the smallest animals, up to about 20 g. Males have small (4 mm. or less in length) testses with no development of the epididymis. Females show no evidence of reporductive activity (no corpora lutea, vagina not perforated).

Subadults. Males have some development of the testes, but the epididymis is barely noticeable, if at all. Females may have a more prominent reproductive tract, and perforated vagina, but no macroscopically visible embryos. Weight may range up to 30 g., although most evidently reach sexually maturity when smaller.

Adults. Males have highly enlarged testes with the epididymis developed. Females either have embryos or show evidence of nursing--enlarged nipples or mammary gland development. In the absence of any other criteria, comparitively large animals were called adults.

Citellus columbianus: Since all young were born in early April, all that were trapped were either subadults or adults. These were separated on the basis of size and evidence of reproduction--mammary gland development and placental scars in female adults and enlarged testes in male adults.

Eutamias ruficaudus and Eutamias amoenus: All young were born in May, so aging was done by size and reproductive evidence, as for C. columbianus.

For all species mammary gland development and enlarged nipples were noted only where their development was considerable. The testes and epididymis were enlarged in all adult male Peromyscus and Microtus.

APPENDIX B

FLUORIDE CONTENT OF COMMERICAL FERTILIZERS SOLD BY MONTANA FLOUR MILLS

Missoula, Montana*

Fertilizer Composition	Fluoride Amount
$K-N-PO_4$	
16-48-0	1.4%
13-13-0	1.6%
27-14-0	.58%
11-48-0	1.97%
16-20-0	1.34% (most common in Missoula)
0-45-0	2.34%

*Montana Flour Mills receives fertilizers from Cominco at Trail, B.C., Canada, and from Simplot at Pocatello, Idaho.